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ABSTRACT

This packet includes a leader's guide, a quick reference guide to aquatic invertebrates, a checklist of common aquatic invertebrates, and activity sheets. The leader's guide includes four sections on background information and seven activities. Background sections include: Understanding Aquatic Insects; Growing Up: Aquatic Insect Forms; Adapting to Life Underwater; and Profiles of Common Aquatic Invertebrates. Activities include: The Aquatic Safari; Making an Aquatic Insect Collection; Presto, Change-o; Create a Critter; The Waterwatchers' Worry; Word Jumble; and Weaving the Web. Appendices contain directions for building sampling equipment and a list of resources. (JRH)

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Pond and Stream Safari

A Guide to the Ecology of Aquatic Invertebrates

A Cornell Cooperative Extension Publication

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Contents

- Leader's Guide
- Quick Reference Guide to Aquatic Invertebrates
- Checklist of Common Aquatic Invertebrates
- Activity 1: Aquatic Safari Record Sheet
- Cards for Activity 3
- Player's and leader's cards for Activity 4
- Work sheets for Activities 5, 6, and 7

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Pond and Stream Safari

A Guide to the Ecology of Aquatic Invertebrates

Karen Edelstein

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Illustrations by Tamara Sayre

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Cornell Cooperative Extension
Helping You Put Knowledge to Work

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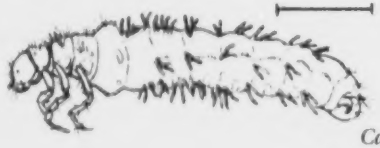
IMAGINE being in the woods by a stream in the early summer. Sunlight is filtering through the trees, and the sun's reflection off the water makes you squint. You sit on a stone by the banks of the stream, the cool water just covering your ankles. You can hear the low hum of insects all around you. A small fish snaps a beetle from the water's surface. A fat, green frog catches a damselfly on its tongue and plops into the stream. Dragonflies dart by, a few black flies try to bite you, and hundreds of delicate mayflies rise and fall together in a silent vibrating cloud.

The insects you see are flying now. But did you know that most of them have spent almost all their lives underwater? Until they became adults, those insects were aquatic, and they looked and acted much differently than they do now. Aquatic insects live in water and form a vital link in food chains. Without them, life in ponds and streams would be very different. Aquatic insects provide a fascinating and readily available means of exploring aquatic ecology with young people.

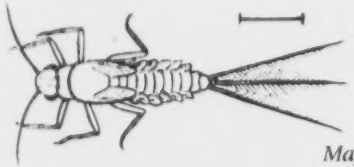
Understanding Aquatic Insects

Many insects lay their eggs in water. The young, or immature, insects grow and develop in water. When they are mature and ready to become adults, they go through a great change called *metamorphosis*. After this change some may stay near water to eat and mate, but they no longer live in water. Insects that spend the first part of their lives in water include caddisflies, mayflies, and stoneflies. Other insects spend their entire lives in or on water. Examples of these are water scorpions, water striders, and many beetles.

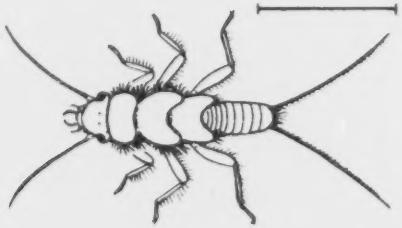
Ruled lines show actual average size of insects or other invertebrates.



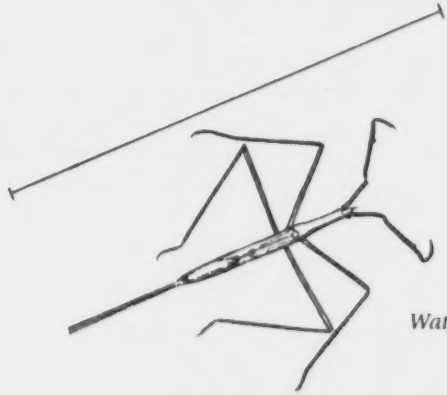
Caddisfly larva



Mayfly nymph



Stonefly nymph



Water scorpion

Water strider

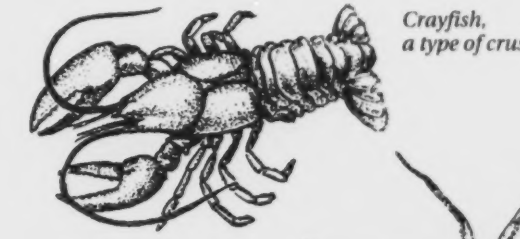
Diving beetle

An insect is an invertebrate. Invertebrates, unlike humans, snakes, or fish, don't have a backbone or an internal skeleton to support their bodies. Instead of a skeleton, invertebrates may have a hardened body (for example, beetles) or a protective shell (for example, snails). Other invertebrates have soft bodies, such as grubs and worms.

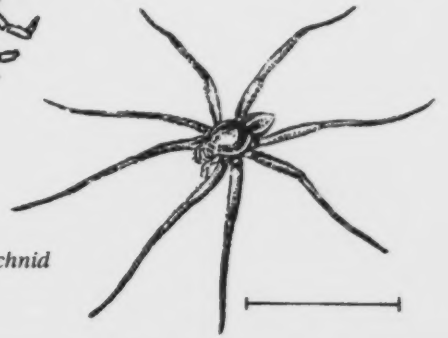
You may see crayfish and spiders in water, but they are not insects. Count their legs and look closely at their bodies. Do they have six legs and three distinct body segments—the characteristics that distinguish insects from other invertebrates? If not, they are not insects. Crayfish and spiders are examples of two other kinds of invertebrates that live in ponds and streams. A crayfish is a crustacean (crus-tay´-shun), and a spider is an arachnid (a-rack´-nid). Crustaceans have eight or more legs and a hard body shell. Arachnids have eight legs and their bodies are usually round.

Common aquatic crustaceans in North America include crayfish, scuds, and aquatic sowbugs. There are also very small crustaceans that you would need a microscope to see. Although tiny, they are valuable sources of food for larger invertebrates as well as for fish. Examples of tiny aquatic crustaceans are water fleas (such as *Daphnia*), copepods, and seed shrimp. In ponds a common aquatic arachnid is the small red mite.

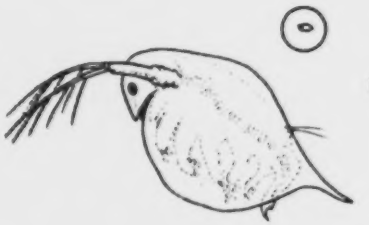
Although crustaceans and arachnids are important members of the aquatic world, aquatic insects occur in the greatest variety. There are thousands of species of aquatic insects.



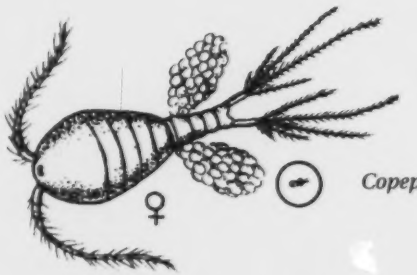
Crayfish, a type of crustacean



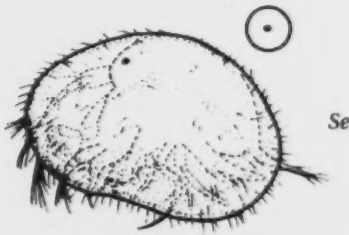
Spider, a type of arachnid



Water flea



Copepod



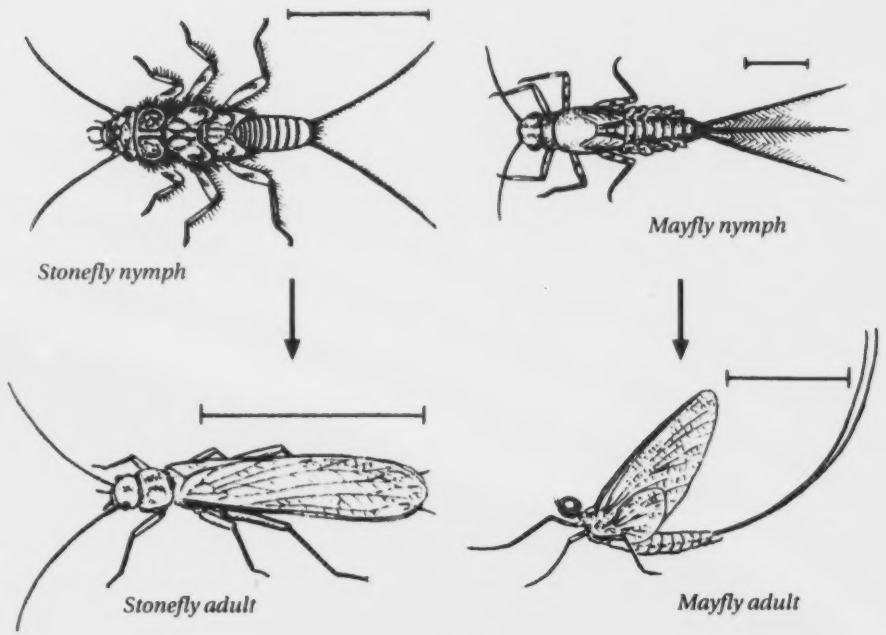
Seed shrimp

Microscopic crustaceans

Growing Up: Aquatic Insect Forms

The bodies of humans change a great deal as they grow from babies to adults. Insects change too, from immature insect to adult, when they go through metamorphosis. The bodies of some insects change completely in form as they grow. These young insects are called *larvae* and they look very different from their parents. The change they go through is called complete metamorphosis.

With other insects, you can look at the immature insect and often predict more easily how it will look as an adult. These young insects are called *nymphs*, and they resemble their adult parents more than larvae do. As nymphs grow into adults, they go through what is called incomplete metamorphosis.



Aquatic nymphs become flying adults.

Aquatic Insects That Go through Complete Metamorphosis

Most people know that caterpillars (larvae) become butterflies (adults). When caterpillars turn into butterflies, they go through complete metamorphosis. Wings develop, reproductive organs form, eyes and mouthparts may change, and legs lengthen. Examples of aquatic insects that go through complete metamorphosis are illustrated here. To learn more about each aquatic insect, see "Profiles of Common Aquatic Invertebrates," starting on page 34.

Monarch butterfly (adult)

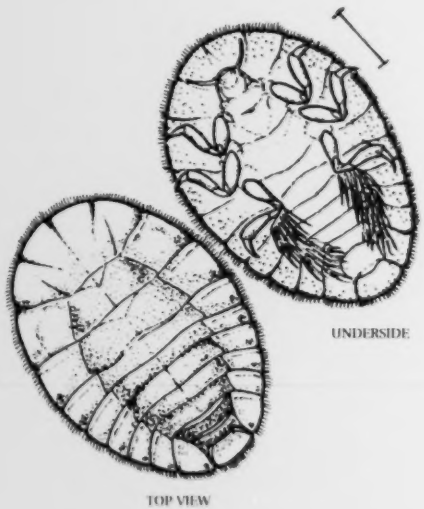
Monarch caterpillar (nonaquatic larva)

A close relative of the butterfly, which spends its entire life on land, is the caddisfly. Caddisfly larvae have soft bodies and are similar in many ways to small caterpillars except that they live in water. Caddisfly larvae can be found in both flowing streams and still ponds. They go through complete metamorphosis to become flying insects.

Caddisfly adult

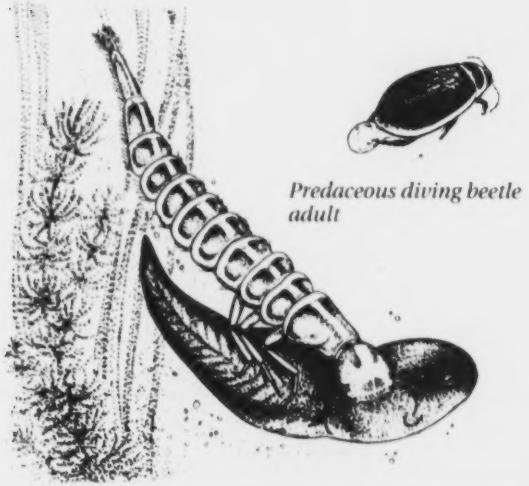
Caddisfly larva

Water pennies are very flat and round, like a penny. Water pennies live underwater on the surfaces of rocks. They turn into adult beetles, which live along the edges of creeks but rarely go into the water.



Water penny beetle larva

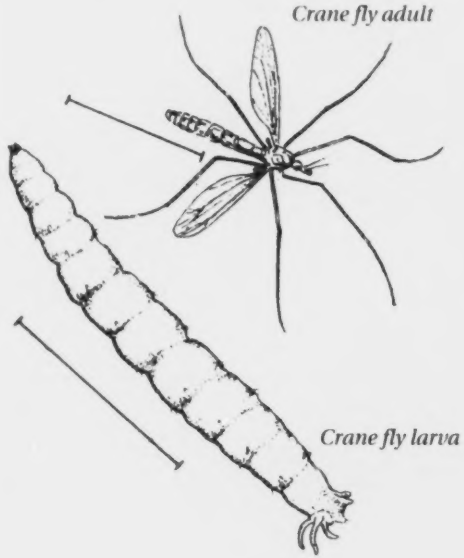
Not all aquatic beetle larvae look like the water penny. Many are long and narrow with large jaws. Some adult beetles, such as the diving beetle and the whirligig beetle, live in water.



Predaceous diving beetle adult

Predaceous diving beetle larva with tadpole prey

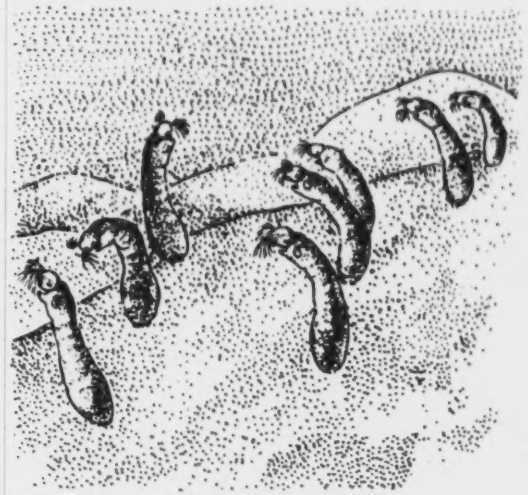
Crane fly larvae are fairly large (½ inch to 2 inches, or 1.3 cm to 5 cm) and live in water. They resemble fat, light-colored worms. Crane fly adults look like giant mosquitos, but they don't bite.



Crane fly adult

Crane fly larva

Black fly larvae are small, about ¼ inch (6 mm) long. They are usually found tightly grouped on rocks in fast-moving sections of creeks (riffles). About mid-May, black fly larvae become flying, biting adult black flies, which spend all their time in the air.

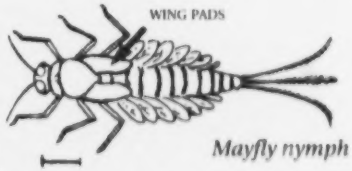


Black fly larvae

Aquatic Insects That Go through Incomplete Metamorphosis

The immature forms of some aquatic insects look a lot like the adults. Their growth from immature insect, or nymph, to adult takes place gradually, without distinctive physical changes. Unlike larvae, nymphs have adult characteristics such as small wing pads and fully developed legs. As they get older, they look more and more like their parents. (As kids get older, they look more like adults too!) Examples of aquatic insects that go through incomplete metamorphosis are illustrated here. To learn more about each aquatic insect, see "Profiles of Common Aquatic Invertebrates," starting on page 34.

Most mayfly nymphs live in fresh, running water. Some are found in ponds and lakes. They can be found living under and on submerged rocks, burrowing in the silt, and swimming in the water. The mayfly nymph has obvious wing pads, which turn into true wings when it becomes an adult.

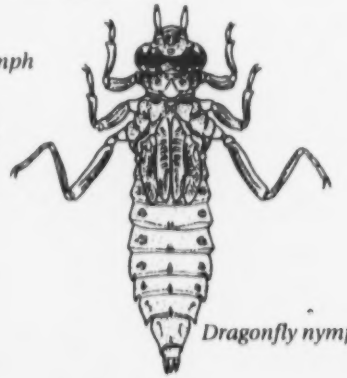


Mayfly nymph

Mayfly adult

Well-developed wing pads are also noticeable on dragonfly and damselfly nymphs. Damselflies and dragonflies are close cousins. Damselflies have more delicate bodies than do dragonflies, both as adults and as nymphs. You can find the nymphs of both in water samples taken from around pond plants and along the edges of streams in clumps of leaves.

Damselfly nymph

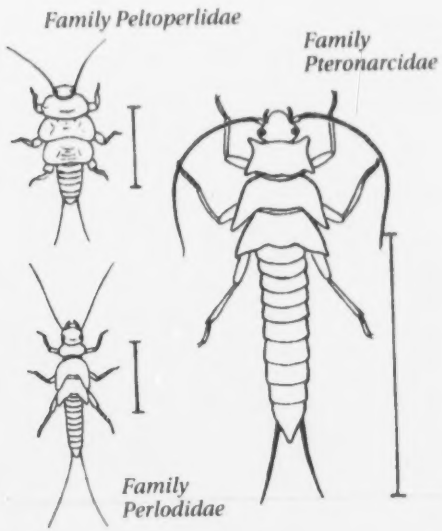


Dragonfly nymph

Damselfly adult

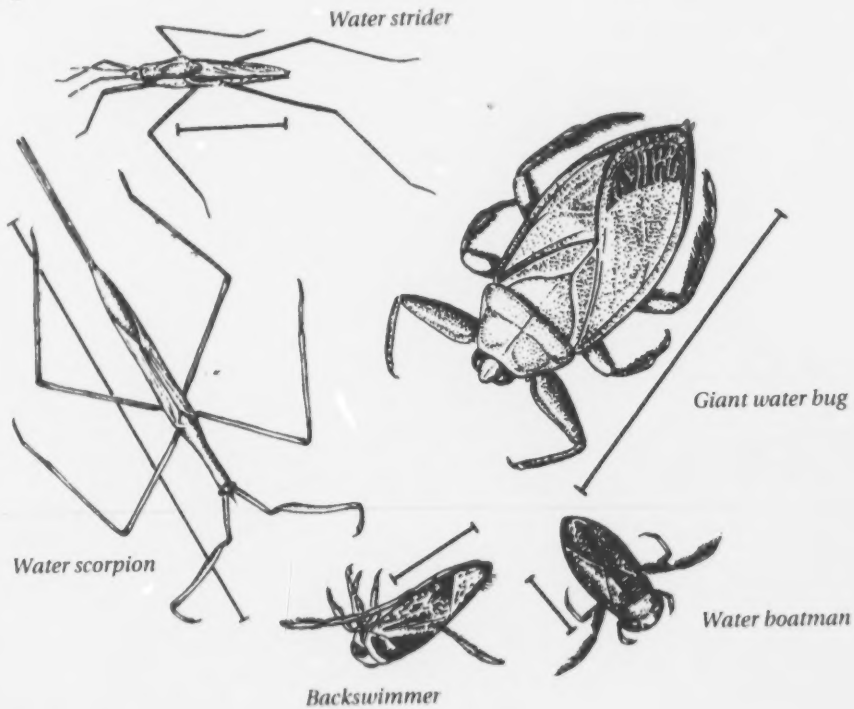
Dragonfly adult

Stonefly nymphs live only in streams with very cool and quickly flowing water. You will always see two tails on the end of a stonefly nymph. Like dragonfly nymphs, stonefly nymphs have obvious wing pads on their backs.



Stonefly nymphs

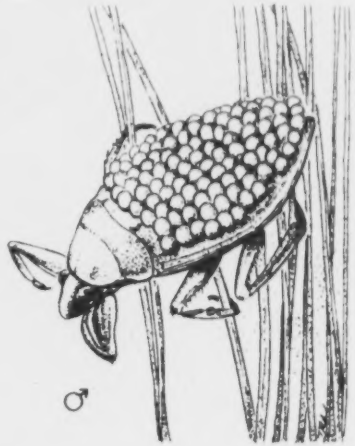
Water striders, water scorpions, water boatmen, giant water bugs, and backswimmers (all in the insect group, or order, called true bugs) go through aquatic nymphal stages too. When they become adults, however, they stay in the water.



True bugs

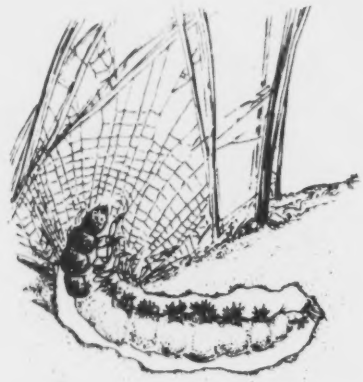
Aquatic Insect Believe It or Not

- Whirligig beetle adults zip around the water's surface at speeds of up to 3 feet (1 meter) per second. This means that the whirligig beetle can propel itself a *thousand* times its body length in just the blink of an eye.
- The eggs of the giant water bug are carried on the back of the adult male—not the female.



- Water striders locate prey, as well as mates, by sensing vibrations on the water's surface through their feet.

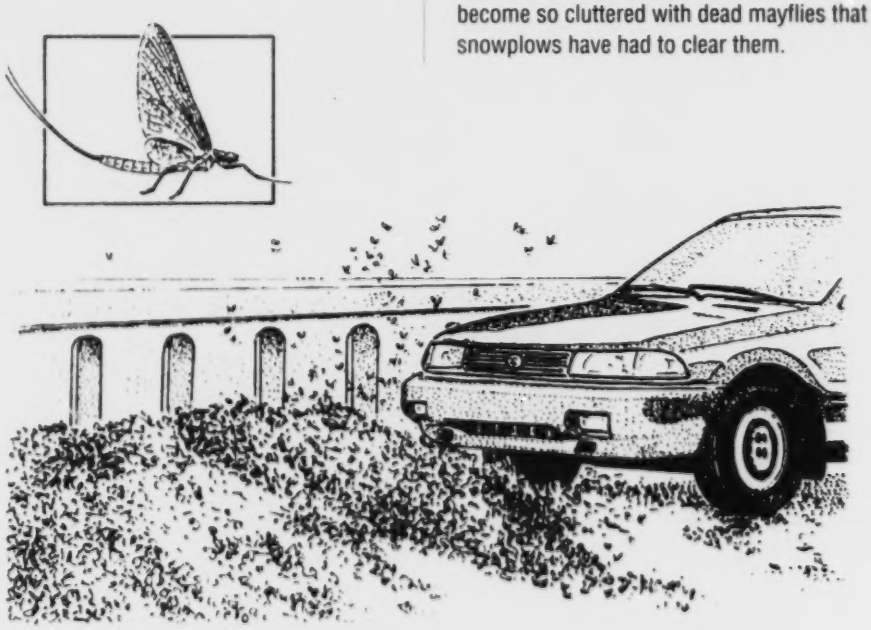
- Dragonfly adults are capable of bursts of speed in the air of up to 75 miles (120 km) per hour.
- Some caddisfly larvae spin silk to make their own underwater net houses. To ward off intruders, they rub their forelegs against their head to create threatening sound vibrations.



Caddisfly larva (family Hydropsychidae)

- Dragonflies have changed very little since the Carboniferous Age 300 million years ago—except for one big difference. The wingspan of prehistoric dragonflies sometimes exceeded 3 feet (1 meter)! Today the largest dragonflies have wingspans of about 4 inches (10 cm).
- Different species of stonefly nymphs change into adults year-round. If you see an insect flying around on a cold winter's day or crawling on snow or ice, it is probably a stonefly.
- The whirligig beetle is a fascinating insect, most often found in ponds and in the still areas of streams. The shiny black adult whirligigs congregate in groups, spinning around each other like bumper cars. If disturbed, they scatter in every direction and then recongregate. Adults are almost always found on the surface of water. Whirligig beetles have two pairs of eyes, one pair above the water and one pair below. The adults use their below-water eyes to hunt for small prey.

- Giant water bugs inject enzymes into their prey, which dissolve the internal body parts of their victims. Then they suck out the liquefied insides. In this way, a giant water bug can ingest prey many times its size, such as frogs and young fish.
- When some species of mayfly nymphs change into adults, they live only two hours. Mayfly adults do not even have working mouthparts, so they can't eat. All they do is mate and lay eggs. Mayfly nymphs somehow know when other nearby mayflies of their species are changing into adults and they change too. As a result, thousands of mayflies are ready to mate at the same time before they die. At certain times of the year, some small bridges over streams have become so cluttered with dead mayflies that snowplows have had to clear them.



Mayflies* (Hexagenia) *after mass emergence from a stream

Adapting to Life Underwater

To live underwater, all invertebrates must have ways to

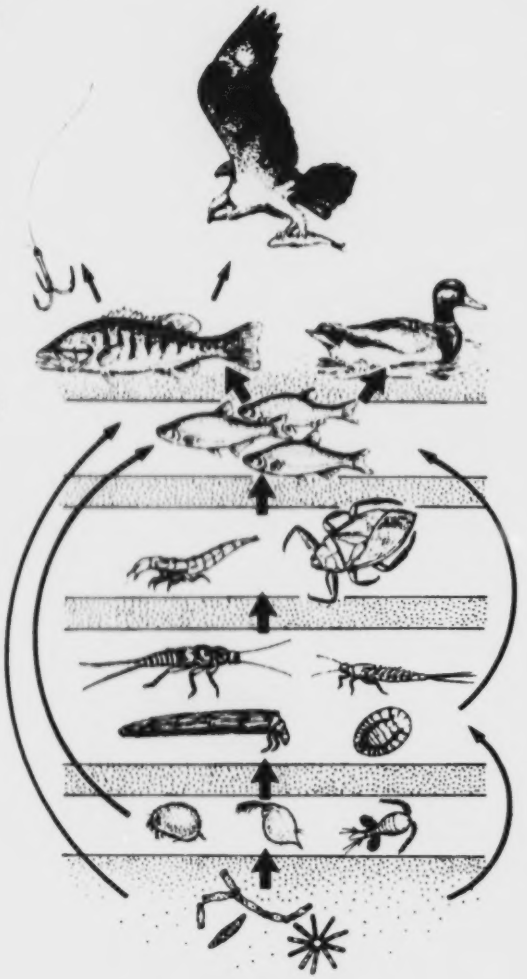
- get food
- move
- breathe

You and your group can discover a lot about how aquatic invertebrates meet these needs by observing one in the water and asking: Where does it live? Does it attack other animals for food? How does it move? How does it get oxygen? This section should help you discover some of the answers to those questions. When you and your group are on your pond or stream safari looking for aquatic insects, use your imagination to help you discover more about aquatic life.

Getting Food

The diets of aquatic insects vary. Some insects eat plants, some eat small animals, and some eat decaying things. Others eat some of everything—plants, animals, and decaying matter. Insects also provide food for larger creatures such as fish, which may eventually be food for you.

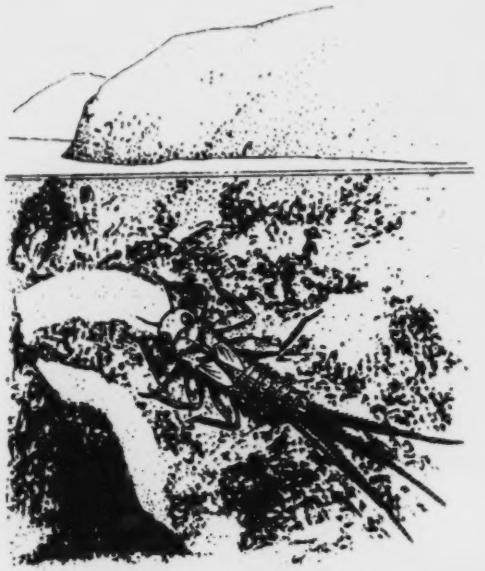
Plant-eating insects, animal-eating insects, and insects that eat decaying matter—all are essential links in the web of aquatic life.



The aquatic food web

Herbivores

Animals that eat plants are called herbivores. Aquatic insects and other invertebrates that eat algae and other green plants play an important role in keeping those plants from growing out of control. If the green algae in a stream is abundant, for example, invertebrates help reduce the levels by feeding on it. Many species of mayflies scrape algae from rocks. Water pennies also get most of their food by grazing on algae that grow in a thin layer on the surface of rocks. A few kinds of stoneflies are also herbivores.



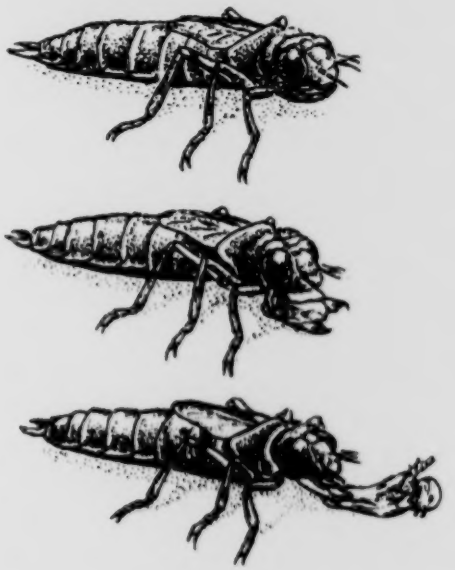
Mayfly nymph grazing on algae in a stream

Predators

A predator is an animal that eats other animals. The nymphs and adults of water scorpions, giant water bugs, water striders, and backswimmers are nearly all predators. Insect predators eat other insects, fish, microorganisms, and even frogs. True bugs use their sharp "beaks" to inject enzymes into their prey. The enzymes dissolve the internal body parts. True bugs then suck out the body fluids of their prey, leaving little more than a shell of the animal's body.

A giant water bug (a true bug) with fish prey

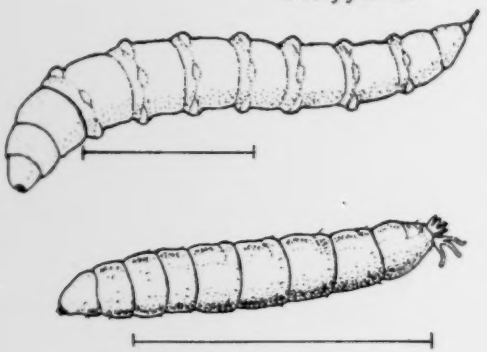
Other successful aquatic predators are dragonfly and damselfly nymphs. Both have excellent eyesight and mouthparts that are well adapted to catching prey. The nymphs lie still and ambush their prey at lightning speed. The lower "lip" of the nymph's mouth is hinged and can extend far past its face to grab a tasty morsel that is swimming by.



Dragonfly nymph using its hinged lip to capture a mosquito pupa

Many fly larvae aren't strong swimmers, so they rely on ambushing prey that come close. In fact, a horse fly larva has been known to attack and eat a small toad.* It's not always the toad that eats the fly in the aquatic world!

Deer fly larva



Crane fly larva

*See R. Jackman, S. Nowicki, D. J. Aneshansely, and T. Eisner, "Predatory Capture of Toads by Fly Larvae," *Science* 222: 515–16, 1983.

Scavengers

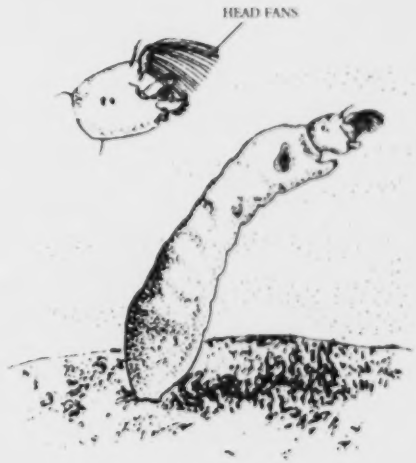
Scavengers eat dead and decaying things, mostly dead plants. Bacteria that live on decaying matter provide high-protein food for scavengers. Aquatic insects that are scavengers include most caddisfly larvae, some mayfly nymphs, mosquito larvae, and rat-tailed maggots, which are a type of fly larva. Crustaceans that are scavengers include crayfish and aquatic sowbugs.

Omnivores

Aquatic insects such as water boatmen, crane fly larvae, and some midge larvae eat plants as well as animals. They are called omnivores, which means "eating all." In other words, they eat some of everything.

Some omnivores are filter feeders, meaning they strain minute particles of food from the water. Filter feeders eat a little bit of every sort of food—small pieces of decaying plants, algae, and tiny aquatic animals. Some filter-feeding insects, such as black fly larvae, have filtering fans attached to their heads. Food particles drifting with the current get caught in the head fans. The black fly larva cleans off the fan into its mouth.

Another filter-feeding insect is the net-spinning caddisfly (family Hydropsychidae). It spins a net, similar to a spider's web, that faces into the current. When enough food particles are caught in the net, the caddisfly consumes the net, food and all, and then spins another one.



A black fly larva filter-feeding in a current

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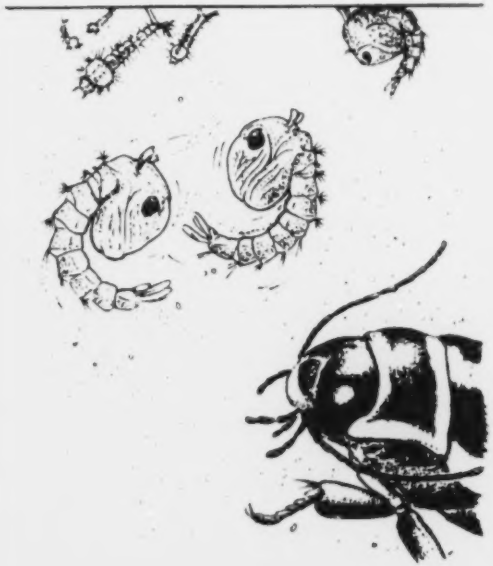
Moving

Insects that live in a stream or pond must be able to move. They need to move for several reasons:

- to escape from predators (mayfly nymphs, mosquito larvae)
- to capture prey or get food (dragonfly nymphs, stonefly nymphs)
- to go to an area where more food is available (black fly larvae, caddisfly larvae, mayfly nymphs)
- to find a new place to live if their original habitat has been changed or disturbed (mayfly nymphs)

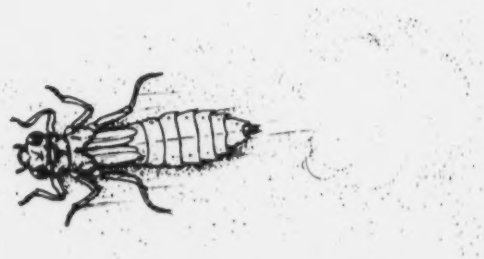
Aquatic insects either move under their own power or drift with the current to get where they need to go. Even if insects swim, they usually are not strong enough to swim against a current.

Some aquatic insects move to escape danger. Mosquito larvae, which usually bob on or just under the surfaces of ponds or very slow-moving streams, avoid threats by diving, tumbling, or wiggling out of the way. Several types of mayflies move so quickly through the water you might mistake them for minnows.



Mosquito pupae, or "tumblers," move away from a predator.

Most aquatic predators move under their own power. Dragonflies, for example, pump water into a chamber at the end of their abdomen and then force the water out, propelling themselves forward. Water boatmen have long hairs on their rear legs. The hairs make the legs wider so they act as oars, moving the insect quickly through the water.

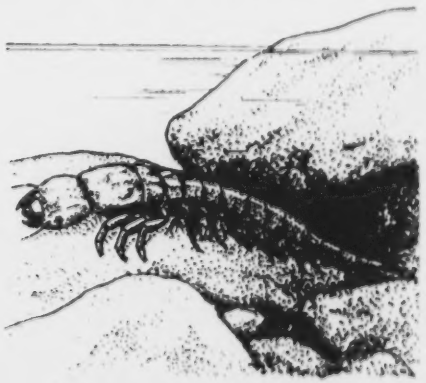


A "jet-propelled" dragonfly nymph

Sometimes natural occurrences, such as floods or landslides, or human-made disturbances, such as dams or construction sites, make a section of a stream unsuitable for some invertebrates. When this happens they must seek better conditions. Stream inhabitants also move when food is no longer plentiful. In those cases, they may drift downstream with the current and settle in a more appealing habitat. Most drift takes place at night when invertebrates are less vulnerable to being eaten by fish.

Some aquatic insects do not need to move quickly. Caddisflies build cases to live in, which provide good protection and camouflage from other creatures that might try to eat them. When caddisflies are threatened, they don't need to swim away; they just pull their heads and legs tightly inside their cases. Nonetheless, sometimes caddisfly larvae are eaten by fish, case and all. Most caddisfly larvae don't need to move to get food because they are filter feeders. They catch food drifting toward them with the current.

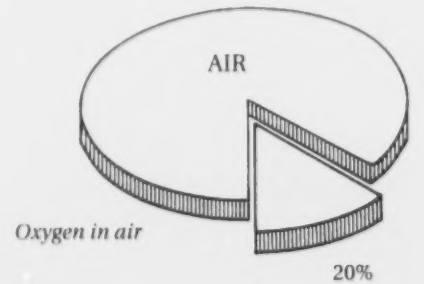
Other aquatic insects avoid predators by hiding. Stoneflies and mayflies lie flat against rocks and crawl between cracks. Hellgrammites, or dobsonfly larvae, are fierce predators themselves, but they hide between rocks to avoid being eaten by larger predators such as fish. The larvae of the alderfly, which is a relative of the hellgrammite, hide in areas of a stream where the bottom is soft.

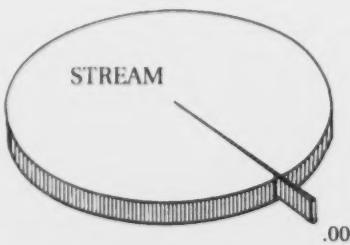


Hellgrammite (dobsonfly larva)

Breathing

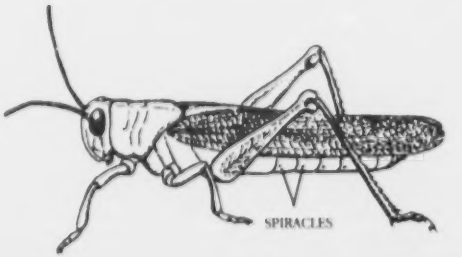
All animals need oxygen to survive. Air is a mixture of many invisible gases, and oxygen accounts for about one-fifth of all the gases. One way animals get oxygen is by breathing it directly from the air. Oxygen molecules are also dissolved in water. Water holds much less oxygen than air, but most of the time the amount of oxygen dissolved in water is enough to sustain fish and many aquatic insects. Polluted water, however, can have dangerously low levels of oxygen.





Dissolved oxygen in a healthy stream

Unlike most of the animals you know, insects do not have lungs. Instead, insects have a network throughout their body of tiny tubes that carry oxygen to their muscles and organs. Insects that live on land have openings for the tubes on the surface of their body. But insects living underwater can't breathe through those openings without flooding their body. Aquatic insects deal with this challenge in several ways.

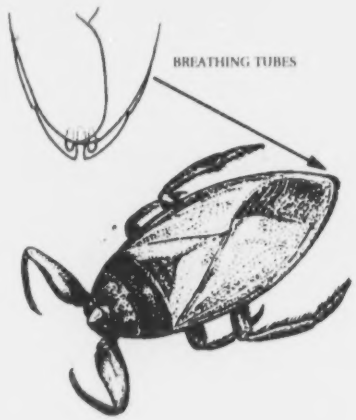


Insects that live on land breathe air through spiracles, or openings that allow air to pass to the inside of their body.

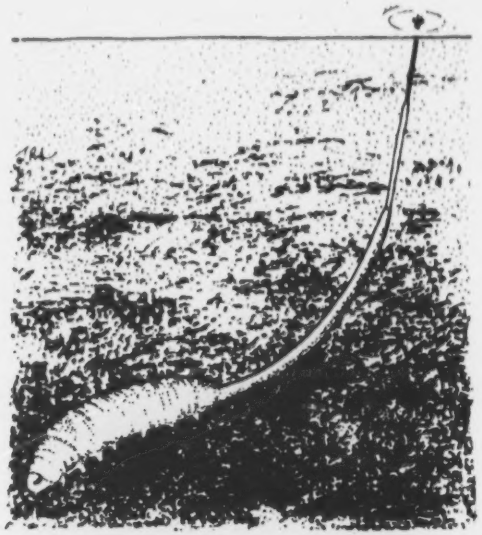
Some insects breathe oxygen from the air. Some aquatic insects use breathing tubes to reach through the water to the air. Breathing tubes are a lot like snorkels. The water scorpion has two long, narrow breathing tubes extending from the end of its abdomen. When you see a water scorpion in water, it is probably moving slowly or drifting just below the water's surface. Why does it hang upside down? The ends of the breathing tubes are just breaking the surface of the water and drawing in oxygen from the air.

Water scorpions get oxygen from the air via breathing tubes.

Giant water bugs, mosquito larvae, and rat-tailed maggots also have breathing tubes at the rear end of their body. Mosquito larvae and rat-tailed maggots can tolerate very polluted water with especially low oxygen levels because they don't breathe dissolved oxygen.

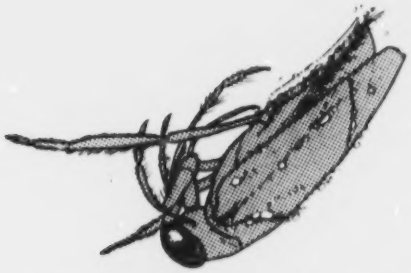


The giant water bug has short breathing tubes that reach to the water's surface.

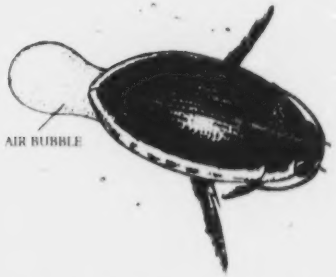


The rat-tailed maggot can live in water that contains almost no oxygen because it breathes atmospheric oxygen through a snorkel-like breathing tube.

Some adult aquatic beetles and true bugs bring air bubbles with them when they dive underwater. If you look closely at those insects, you may see a silvery sheen on the underside of the abdomen. This is a thin layer of air held up by microscopic hairs. Other insects, such as diving beetles, trail a round bubble of air behind them as they swim underwater.



A backswimmer carries a film of air on its body when it dives.



A diving beetle carries an air bubble underwater with it.

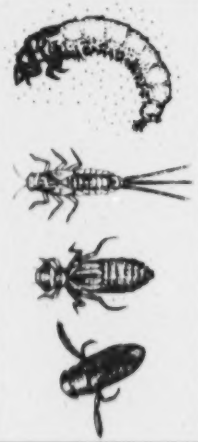
Some insects breathe oxygen dissolved in water.

Water can hold only about 4 to 12 molecules of oxygen in 1 million molecules of water. Scientists express that range by saying water contains from 4 to 12 parts per million (ppm) of oxygen. Because 1 percent (one part per *hundred*) of dissolved oxygen is the same as 10,000 parts per million, 4 to 12 ppm is a very small fraction of 1 percent of dissolved oxygen.

It makes a big difference to some insects whether they can get 4 ppm of oxygen or 12 ppm. Even though 12 ppm seems like a tiny amount of oxygen, it is three times more than 4 ppm and enough for most any aquatic insect to survive.

Many immature aquatic insects, such as stonefly nymphs and water pennies, can live only in water that has high levels of dissolved oxygen. If the level of dissolved oxygen is less than 8 to 10 ppm, they probably will not survive.

Level of Dissolved Oxygen in Water

High *8–10 ppm*	*Medium* *4–8 ppm*	*Low* *0–4 ppm*
Insects That Can Live in Water with That Level		
		
stonefly nymphs water pennies some mayfly nymphs caddisfly larvae	caddisfly larvae some mayfly nymphs dragonfly nymphs many true bugs damselfly nymphs	mosquito larvae midge larvae tubifex worms

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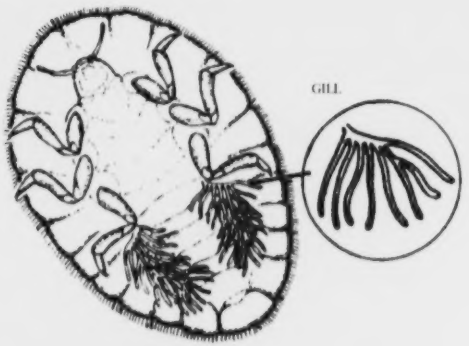
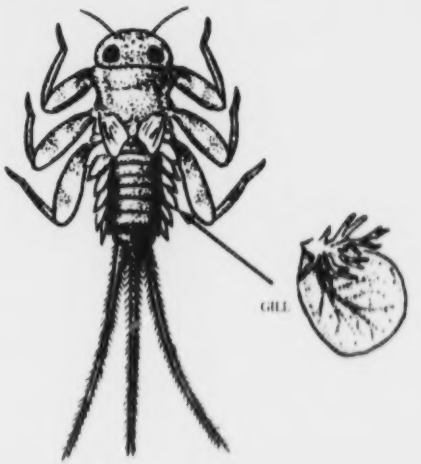
Some insect nymphs and larvae have special gills on their body to help them absorb oxygen from water. Gills help aquatic insects such as some mayfly nymphs and some caddisfly larvae tolerate medium levels of dissolved oxygen. Water pennies have gills that are located behind their last pair of legs.



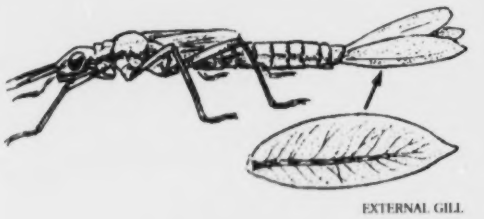
Water penny beetle larva (underside)

The presence of gills can help you distinguish mayfly nymphs from other creatures in a stream. Every mayfly nymph has a row of thin, leaflike gills extending down both sides of its abdomen. By moving the gills rapidly, the mayfly keeps a current of water flowing over its gills. The more water that the mayfly can make flow over its gills, the more oxygen it can extract from the water.



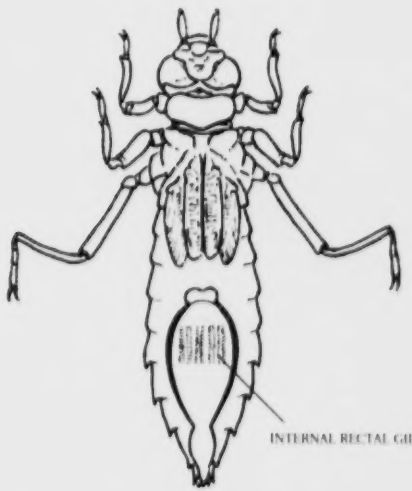
Mayfly nymph (family Heptageniidae)

Some caddisfly larvae get their oxygen through short, tufty or fingerlike gills on their abdomen. The gills of damselfly nymphs look like paper-thin leaf-shaped tails.



Damselfly nymph

The damselfly's cousin, the dragonfly, also has gills. But instead of projecting outward from the body, they are inside the body. The dragonfly nymph draws water into a chamber at the end of its abdomen, creating a current across the gills. When the oxygen in that water has been taken up by the gills, the nymph forces the water back out. Not only does this get rid of the used water, but the push of the expelled water moves the dragonfly nymph forward. Dragonfly nymphs can zip around in the water with fast bursts of speed.



Dragonfly nymph

Did You Know?

Why do ponds have less oxygen than streams, especially if the plentiful plant life in ponds produces so much oxygen through photosynthesis?

The running water of a stream, as it tumbles over stones, constantly mixes in oxygen from the air. Streams also are often more shaded and thus cooler than ponds. The cooler the water is, the more oxygen it holds. In contrast, pond water is often stagnant (not flowing) and tends to warm up during the summer. The green plants in ponds produce a lot of oxygen, but only during the day. At night, the same plants use up most of the oxygen they made during the day. Also, when plants die, oxygen is used up by the micro-organisms that eat the decaying plants.

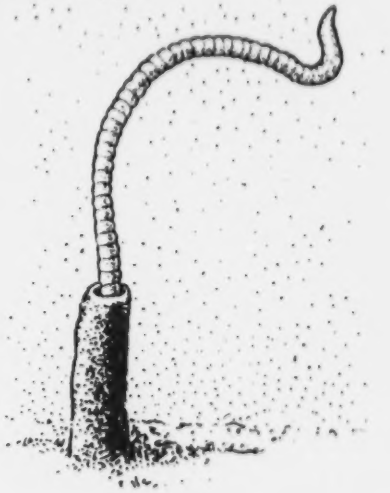
Unrefrigerated soda pop sprays when opened because gases (carbonation) do not stay dissolved in warm liquid as well as they do in cool liquid.

Instead of absorbing oxygen through gills, certain pond and stream invertebrates breathe through the surface of their body. These animals are often extrasensitive to decreases in levels of dissolved oxygen and are not found in water unless the dissolved oxygen content is high. Some caddisfly larvae absorb oxygen across the entire surface of their body. Scientists have observed caddisflies in their cases moving their bodies in a waving motion, which creates a current that supplies more oxygen.

A caddisfly larva moves its body to increase the flow of oxygen-rich water inside the case.

Caddisflies are not the only aquatic insects that can absorb dissolved oxygen directly. Black fly, midge, and crane fly larvae and some species of stoneflies also absorb oxygen across the surface of their body.

When the oxygen dissolved in water drops below levels that are normally deadly to most other aquatic invertebrates, the tubifex worm survives by becoming inactive. This special worm burrows itself deep into mud and moves very little. Tubifex worms are common to polluted waters, which often contain little or no dissolved oxygen.



Tubifex worm

Red midge bloodworms (the larvae of a small fly) have an unusual method for storing oxygen. The larvae are red because their body fluids contain a substance similar to hemoglobin, which gives human blood its red color. This red pigment carries oxygen in the bloodworm's body fluids and reduces the need of the larva to replenish oxygen frequently. Midge larvae are abundant in ponds and streams, and they are a common source of food for other invertebrates and fish.

You're Ready

The inhabitants of the worlds beneath the surfaces of most streams and ponds can teach you a lot about nature. You will probably see many things that haven't even been discussed in this guide. By exploring and observing, you will learn more through your own experiences (and growing knowledge) than you could from a book. Let your observations be your guide. Have fun!

ACTIVITY 1 The Aquatic Safari

Your group is in for a big adventure and lots of surprises when you stalk and collect aquatic creatures. An aquatic safari is different from a safari in Africa, however—you don't need to travel far to get there, the animals you'll be looking at are no bigger than your smallest finger, and you'll release everything that you catch alive.

You can collect and observe dozens, even hundreds, of insects in a single pan of stream water. Shallow streams with clear, cold running water are good habitats to sample. If your group members wade in a stream, they can pick up rocks and find many immature insects (nymphs and larvae) clinging to them. The only tools they will need for sampling are their hands, their eyes, and a shallow white-bottomed pan.

If your group is collecting samples from a pond or a stream with a sandy or silty bottom, they'll need nets to catch insects. In a pond, they will find the most insects in and around the aquatic plants along the water's edge.

Caution: Make sure the youths work in pairs, and remind them that areas around streams and ponds can be slippery. When they are walking in a stream, encourage them to step cautiously and use a pole or net handle for support if necessary. Appropriate footwear (old sneakers, rubber boots) is essential, for there may be broken glass and sharp rocks on the bottom.

Take your group sampling in a stream and record what insects you see. Then go to a pond and record what you find there. Encourage the youth to think about their discoveries by asking the following questions: How do the insects in ponds behave compared with those in streams? Where are the insects larger? Better camouflaged? Faster moving? More aggressive? In greater numbers? More varied in size and shape?

Don't worry if you and the members of your group cannot identify every creature you collect by its proper name. Instead, look for characteristics that distinguish one organism from another. You'll be surprised how much you and your group will discover together about aquatic ecology.

Before You Begin

Take a few moments to discuss with your group the importance of insects and other invertebrates to aquatic food webs. Invertebrates provide food for a lot of other life in ponds and streams, particularly fish. Fish are food for many types of water birds, such as herons, eagles, and osprey, as well as for humans.

The respect that you and your group give to the creatures in the habitats you sample is an expression of how you care for the whole environment, because all creatures, including people, are interconnected. Although some insects may die in the process of collecting, emphasize to your group the importance of returning as many as possible alive to the stream or pond.

Note: If you think the stream from which you and your group are going to collect samples may be considered a sensitive trout stream by the agency that oversees fish and wildlife management in your state, check with your conservation officer before bringing your group to the site. The conservation officer may have suggestions about alternative sampling sites to choose. You may need to apply for a collection permit to sample there or to preserve organisms in alcohol for a permanent collection. In New York State, such a license costs $10 per year. Write to Special Licenses Unit, New York State Department of Environmental Conservation, Division of Fish and Wildlife, 50 Wolf Road, Albany, New York 12233-4752.

What You'll Need

- a shallow white-bottomed pan for each pair of youths (Use a plastic pan or an observation tray made from a half-gallon milk carton. Instructions for making a white observation tray are in the Appendix.)
- a D-net, a small-meshed seine, or a similar collecting net for each pair of youths (Instructions for making a D-net and a seine are in the Appendix.)
- bug boxes (optional—see the Appendix for ordering information)
- eyedroppers (optional)
- tweezers or small forceps (optional—see the Appendix for ordering information)
- plastic spoons for scooping up aquatic insects for a closer view
- copies of the "Checklist of Common Aquatic Invertebrates" for each member (in folder)
- copies of the Aquatic Safari Record Sheet for each group member (in folder)

What to Do

Divide your group into pairs. Have each pair of youths fill a shallow white-bottomed pan or basin with about 2 inches (5 cm) of clear water from the stream or pond you are sampling. Demonstrate to your group the collection technique using a D-net or a seine. Then supervise them as they collect their own samples. When they are finished, have each member of your group complete the Aquatic Safari Record Sheet.

Collecting with a D-Net

1. If youth are collecting in a stream or shallow river: Stand in the stream, facing downstream. Holding the long handle of the D-net, set the net on the bottom of the stream 1 to 2 feet (30 to 60 cm) away from you, with the opening facing upstream (toward you). Kick the bottom of the stream directly in front of you. Animals living under and between the rocks will be knocked loose and drift with the current into your net. You also can make several sweeps upstream from where you are standing to collect animals that may be swimming or living in the water just above the bottom.

If youth are collecting in a pond or lake: Standing either in shallow water or along the shore, sweep the D-net through the plants along the edge of the water four or five times. Invertebrates hiding in the plants will be knocked loose and caught in the net. If you are standing in the water, kick up the bottom of the pond or lake, then sweep through that area with the net.

2. When you get back to the shore, dump the contents of the net into the observation pan. Turn the net inside out and swish it in the water to release creatures that may have stuck to the mesh. Emphasize to your group that although the net may appear empty at first, only when they swish the net in the water in the pan will all creatures be released.

Note: When using a D-net, it is best to keep sediment from accumulating in the net during sampling sweeps. When too much sediment is transferred to the observation pan, it is very difficult to observe living creatures. If the water is murky or muddy, make fewer sweeps, or move on to an area where the water is clearer.

Collecting with a Seine

1. If youth are collecting in a stream or shallow river: Two persons are needed to use a seine; each partner holds one pole in a vertical position with the net opened between them. Keeping the bottom of the net close to the bottom of the stream, walk slowly upstream, against the current, for two or three minutes. Ask a third person to agitate a small area of the stream bottom upstream of where you and your partner are standing; this action releases more creatures from the bottom.

If youth are collecting in a pond or lake: The procedure is similar, except that you and your partner do not need to walk in a particular direction because there is no current. Sample for about two to three minutes, including a pass through vegetated areas to collect creatures that may be hiding in the plants.

2. To remove the net from the water, keep the top edge of the net steady while carefully lifting from the bottom edge of the net. When the net is out of the water, it should be in a horizontal position. Invertebrates and fish will be trapped on the top of the net.

3. Bring the net back to shore in the same position and gently set it down on the ground. Examine the surface of the net for invertebrates that may be trapped by the mesh, and gently pick them off and place them in the observation pan.

4. When you have transferred the creatures from the net to the pan, immediately rinse the net off in the water, freeing any invertebrates that you may have overlooked.

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Observing the Samples

1. Allow the debris and sediment in the water in the observation pan to settle. It may take a minute or two for the water to clear.

2. Observe with your group the movement of the creatures in the pan. Ask your group the following questions: How do the animals they see get air? Do they hide from light? Do they sit still or move around? How many different kinds of creatures are there? Are there any small fish? Are there small, dotlike creatures flitting in the water? (These are plankton.)

3. Animals that are less than 1 inch (2.5 cm) long can be placed in a bug box for closer inspection. Be sure to put about ½ inch (12 mm) of water in the box first. Pick the animals up gently with a plastic spoon or a forceps, taking care not to squeeze them too tightly. Very small insects and worms can be drawn up into an eyedropper and then released in a bug box. Do not leave insects in the bug box for too long (more then 30 minutes) or they will use up all the oxygen that is in the water. Place them gently back into the observation pan. When your group is finished observing the sample in the pan, you should return the water carefully to the pond or stream that it came from.

4. Demonstrate returning the contents of your pan to the pond or stream, and then supervise the youths as they empty their pans. Restoring the aquatic invertebrates to their own habitat is one of the most important steps in this activity.

5. Have each group member complete the Aquatic Safari Record Sheet.

Additional Activity

Have the members of your group collect samples from both the pools and the fast-flowing areas (riffles) of a stream. Compare the types of animals found in the different habitats. In the same way, have them collect samples from both the open water and the vegetation in ponds. Compare the creatures found in these different habitats.

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ACTIVITY 2 Making an Aquatic Insect Collection

Collections are a good way to display examples of insects. They can be used at fairs or demonstrations, when it is not possible to have living examples. Although insects are most interesting when you can see them moving around and interacting, you and your group also can learn a lot from preserved samples. For example, you can see more of the insect's anatomy when it is not moving.

Unlike preserved collections of flying insects such as butterflies and bees, collections of aquatic insects must be kept moist. Aquatic insects should be preserved in alcohol, *not* in water, where specimens will decompose.

After your group has collected samples and the sediment has settled in the collecting pan, observe the insects swimming and crawling around. Try to take only one or two of each kind from the pan to preserve. The more insects that are returned alive to the creek or pond, the better. Be sure to stress to your group members that it is not necessary to preserve all the specimens.

Note: If you think the stream from which you and your group are going to collect samples may be considered a sensitive trout stream by the agency that oversees fish and wildlife management in your state, check with your conservation officer before bringing your group to the site. The conservation officer may have suggestions about alternative sampling sites to choose. You may need to apply for a collection permit to sample there or to preserve organisms in alcohol for a permanent collection. In New York State, such a license costs $10 per year. Write to Special Licenses Unit, New York State Department of Environmental Conservation, Division of Fish and Wildlife, 50 Wolf Road, Albany, New York 12233-4752.

Before You Begin

A collection of aquatic insects will last for many years and will be a good reference as youth learn more and more about the diversity of insects living in the ponds and streams in their area. The following are examples of interesting exhibits your group can make:

- A comparison of preserved insects and the tied flies they imitate
- A demonstration of the life cycle of one or more aquatic invertebrates, from egg to nymph (or larva) to adult to egg
- A display showing the diversity of caddisflies and the cases they make
- A comparison of the body types of different fly larvae
- A display of the insects found in ponds or streams
- A display of the variety of mayfly nymphs (or stonefly nymphs) in a typical stream
- A comparison of the body types of aquatic true bugs

What You'll Need

- collecting pans
- forceps or tweezers
- 8-ounce jars with screw caps, half-filled with 70% ethyl alcohol* or isopropyl alcohol
- empty 8-ounce containers with screw caps
- small glass or plastic Petri dishes
- small glass sample vials with caps or corks
- identification labels for the vials
- a sharp pencil or pen with indelible ink (e.g., a Repitograph)

Caution: Ethyl alcohol and isopropyl alcohol are toxic if ingested. Be sure to stress this fact to the youths in your group. Also, make sure the room in which your group is working is well ventilated.

*Ethyl alcohol, which can be purchased at most pharmacies in 8- or 16-ounce bottles, is preferred.

What to Do

Each youth or group of youths should have a collecting pan with specimens they wish to preserve. Demonstrate to them the following procedure for preserving aquatic insects, and then supervise them as they preserve their own specimens.

1. Using the forceps or tweezers, remove one or two specimens of each kind of insect from the sampling pan and place them in the jar of alcohol. Most insects will die immediately. (Some insects, such as dragonfly nymphs and dobsonfly larvae, take longer to die. Use a separate jar for preserving dragonfly nymphs, because dragonfly nymphs may eat other specimens.)

2. Pour the extra alcohol from your jar into an empty container, and transfer the insects from the jar to a Petri dish. Add just enough alcohol to cover them.

3. Fill the sample vials halfway with alcohol and label each one with the name of the order of insect you can identify (for example, one vial for mayflies, one for stoneflies, and one for caddisflies). Labels can be either stuck on the outside of the vial or inserted into the vial, as long as indelible ink is used. Labels on the outside of the vial are more likely to be lost.

4. Sort the insects and place the appropriate specimens in each labeled jar.

Additional Activity

Scientists classify living things by grouping them into categories based on similar traits. When scientists identify insects, they need to look for those traits, such as the type of mouthparts, the presence of hairs on a part of the insect's body, or the number of claws, to tell one category from another. If you are interested in identifying insects to more specific levels than order (such as family, genus, or even species of the insect), it's helpful to have a dissecting microscope and a good identification guide. Several guides are listed in the Appendix. For background on using identification keys, see 4-H leader's guide L-5-21, *Field Guides Made Easy* (1991), available from the Cornell Resource Center, 7 Business and Technology Park, Ithaca, NY 14850.

ACTIVITY 3 Presto, Change-o

This activity will help your group members become familiar with the differences between immature and mature insects and, as a result, increase their skills in invertebrate identification.

Before You Begin

Have the members of your group bring in old photographs of their parents when they were children, or show them a picture of you when you were a child. Point out that living things change in shape and appearance as they get older and more mature.

Then discuss with your group how the creatures they collect from streams and ponds are many different sizes and shapes. Most are insects, but they do not look like the insects that fly around in the summer. Why? Because many aquatic invertebrates are immature insects—either larvae or nymphs. They live in ponds and streams until they are old enough to develop a full set of wings, fly off, and lay eggs of their own. The change insects go through to become adults is called metamorphosis.

Most larvae are shaped like worms and have soft bodies. Examples of insects that live in water as larvae and then fly away when they become adults are mosquitoes, crane flies, dobsonflies, caddisflies, and midges. One interesting larva that doesn't look like a worm is the water penny. Water pennies grow up to be beetles that live along the banks of streams.

Aquatic nymphs are different from larvae in one very obvious way. Instead of looking like worms, nymphs more closely resemble the adult insects. Their bodies are firmer than larvae and have three obvious pairs of legs. Nymphs also are usually stronger swimmers. If members of your group look closely at a nymph, they will see wing pads, or the beginnings of wings, on its back. As nymphs get bigger, the wing pads grow, and after metamorphosis, the adult has fully developed wings.

In this activity, your group will match illustrations of immature aquatic insects (and some other creatures that live in water) with their corresponding adult forms.

What You'll Need

- one set of cards illustrating adult aquatic organisms (in folder)
- one set of cards illustrating immature aquatic organisms (in folder)
- scissors

What to Do

1. Make photocopies of the uncut card sheets in the folder and have your group cut the sheets into individual cards. Divide the cards into two piles, one for adult forms and one for immature forms, and shuffle each pile.

2. Hand out one card to each youth in your group, making sure that for every adult card distributed the corresponding card for the immature form is handed out.

3. Have the youths look for the card that matches the one they have, so that every pair of youths ends up with a card illustrating the adult and a card illustrating the immature form of an organism. **To help youths match up forms with which they are unfamiliar, the shapes at the right edge (immature) and left edge (adult) of matching cards fit together to form a design.**

4. For large groups, distribute the cards and have the youths form two groups according to where the creature illustrated on their card lives—pond or stream. This information is on each card. Then ask them to proceed as above.

5. When all the cards have been matched, have each pair describe to the group the immature and adult forms of their organism and, for insects, tell why the immature form is a nymph or a larva.

ACTIVITY 4 Create a Critter

Aquatic invertebrates face many challenges to survive. Depending on the specific environmental conditions of their habitat, different animals each have adapted ways to get oxygen, to hide from predators, to move away if their habitat is threatened, and to get food.

This activity will help the youths in your group recognize the characteristics that make aquatic creatures distinct from one another and relate those characteristics to their requirements for survival. Once they understand the needs of individual animals, the group members will be better able to predict where certain invertebrates can be found. They will also gain a greater awareness of the aquatic environment.

What You'll Need

- newsprint or large sheets of plain white paper
- colored markers, crayons, or pencils
- scissors
- one set of players' cards (in folder)
- one set of leader's cards (in folder)

What to Do

1. Give each youth a large sheet of newsprint or white paper and colored markers, crayons, or pencils.

2. Photocopy the uncut players' card sheets in the folder and have your group cut the sheets into individual cards. Do the same with the leader's card sheets.

3. Each players' card gives a brief description either of a physical characteristic, a certain behavior, or how an aquatic creature is adapted to breathe, eat, or move. They are labeled accordingly in one of five categories: Body, Breathing, Eating, Movement, and Other Behaviors. Divide the players' cards into five piles according to their label. Make sure each pile has as many cards as the number of youths participating. If your group is large, there can be duplicate cards in each pile.

4. Have the youths pick one card from each pile and, based on the descriptions on their five cards, draw an imaginary aquatic insect in a habitat.

5. When everyone is finished, have the youths each show the group the creature they have drawn and explain how it has adapted to survive in its aquatic habitat.

6. Using the leader's cards, show what the adaptations look like on real insects. The leader's cards are the same as the players' cards, except with the descriptions there are illustrations of real insects with those adaptations.

ACTIVITY 5 The Waterwatchers' Worry

Aquatic ecologists often use biomonitoring to determine how polluted a body of water might be. Biomonitoring involves sampling the invertebrates in a stream and then identifying them. Because some types of insects and other invertebrates are better able to tolerate pollution than others, the creatures found at a certain site can be an indicator of the quality of the water. Insects are useful as indicators of water quality because they are cheap and easy to collect, they have a life cycle of about one year, and they stay in one part of a stream or a pond for a long time and develop throughout that period. Therefore, they are vulnerable to pollution at any time of the year.

In this activity, your group will consider the living requirements of certain aquatic creatures. For example, does an insect larva need calm water or running water? Is a particular nymph found only in fast-running, cold water? Why might one insect need less dissolved oxygen in water than others?

The work sheet for this activity describes the experience of two youths, Wanda and Willy Waterwatcher, who collect aquatic creatures from various sample sites, and the "worry" they encounter. The members of your group will try to help Wanda and Willy solve their problem using what they have learned on their aquatic safaris. The chart "A Quick Reference Guide to Aquatic Invertebrates" and the "Checklist of Common Aquatic Invertebrates," which are in the project folder, will be helpful references.

What You'll Need

- copies of the activity work sheet for each group member (in folder)
- copies of the "Checklist of Common Aquatic Invertebrates" for each member (in folder)
- the chart "A Quick Reference Guide to Aquatic Invertebrates" (in folder)

What to Do

1. Hand out copies of the activity work sheet to each group member. Ask them to read about Wanda's and Willy's day of sampling and the problem they face identifying the sources of their samples.

2. Have your group work together to identify the sampling sites for jars A, B, and C.

3. Compare their solutions with the correct answers and then explain the correct answers to them.

Answers

Sample A is from the site near a factory. Poor water quality.

Sample B is from the small pond. Good water quality.

Sample C is from the rocky-bottomed stream in the forest. Excellent water quality.

Why?

Sample A—Tubifex worms require very low levels of dissolved oxygen and are often found at sites where high levels of pollution have resulted in large populations of bacteria. The bacteria consume most of the dissolved oxygen and only animals that use oxygen from the air, such as mosquito larvae and rat-tailed maggots, can survive there. These animals have breathing tubes that extend to the air above the water's surface.

Sample B—The water in ponds is usually slightly warmer than water in streams, and therefore dissolved oxygen levels are generally lower. Dragonfly and damselfly nymphs are common in ponds and like to live in the weeds along the banks. Water striders, which cannot swim well against the current, prefer to live on the quiet surfaces of ponds rather than in streams. Water scorpions also prefer quiet ponds, and they are often found hanging upside down from an underwater plant stem. Some mayfly nymphs burrow into the soft bottom of ponds, and caddisfly larvae build cases out of pieces of pond plants. Aquatic beetles live in ponds on the water's surface (whirligig beetles) and underwater (predaceous diving beetles). Bluegills and bass are common to warmwater ponds.

Sample C—Stonefly and mayfly nymphs are common in cool, shaded streams that are fast running and contain high amounts of dissolved oxygen. Crane fly, black fly, and caddisfly larvae and hellgrammites are also likely to be found in streams with cool, clear water and rocky bottoms. The spaces between rocks make good hiding places for these insects as well as for crayfish. Trout and minnows are often seen in cool streams, where they feed on mayflies, stoneflies, and caddisflies.

Questions for Discussion

- Why is there more dissolved oxygen in a fast-flowing stream than in a pond?
- What adaptations would you have if you were an insect living in a stream? In a pond?
- Why do you think certain fish are found in streams but not in ponds? In ponds but not in streams?
- Can fish live at a polluted site?
- If not, can other animals?
- What about people?
- What effect does pollution have on the food that people eat?

Additional Activity

Have your group draw a diagram of a food web for each of the three sample sites. Ask them to keep in mind that one site is severely polluted and the other two are not. Have them try to include plants, insects, fish, and other vertebrates in their food webs. (See Activity 7 for a more detailed exercise on food webs.)

ACTIVITY 6 Word Jumble

Fish and insects are closely associated in the aquatic food web. Because aquatic insects are often the primary food source for fish, the health of the insects in a stream or pond directly affects the populations of fish living there. Much of the time, insects are even more vulnerable to destructive environmental influences than are fish. A diverse community of many different types of aquatic insects and other invertebrates very often indicates that the stream or pond is healthy.

In this word jumble activity, the youth in your group will unscramble words with the help of the clues or definitions given to get a special message.

What You'll Need

- copies of the activity work sheet for each group member (in folder)
- pencils

What to Do

1. Hand out a copy of the activity work sheet to each youth in your group.

2. Instruct them to unscramble each jumbled word using the clues given.

3. At the bottom of the paper, have them write down in order the highlighted letter in each word to see what the special message is.

Answers

mayfly
habitats
crustacean
herbivore
plankton
predator
emerge
order
gills
nymphs
metamorphosis
riffle
scavenger
filter
senses
water
food
season
lure
dragonfly
larvae
spinner
dissolved
bluegill

Special Message: **Fish need insects to survive.**

ACTIVITY 7 Weaving the Web

All creatures that live in ponds and streams rely on other plants and animals for their food. Food is a link between all animals, large and small. Small animals eat plants, and then those small animals are eaten by larger animals. The larger animals are eaten by still larger animals, and so on. These links through eating make up what is called a food chain.

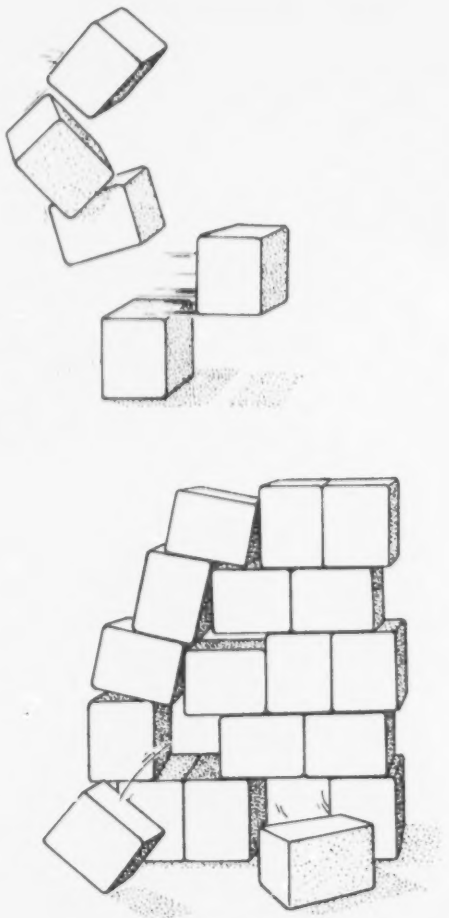
In real life, however, the connections are not so simple. One animal may eat a variety of foods, including plants and smaller animals. Other animals may eat plants, animals, and decaying matter. The chain becomes complicated and is known commonly as a food web.

A basic feature of the food web is a system of checks and balances, which keeps populations of one type of organism from dominating others. For example, algae overgrowth is prevented by a variety of algae-eating invertebrates. The populations of algae eaters are kept in check by their predators, both invertebrates (such as stoneflies and hellgrammites) and vertebrates (such as small fish). Large fish eat small fish, keeping the number of small fish in check.

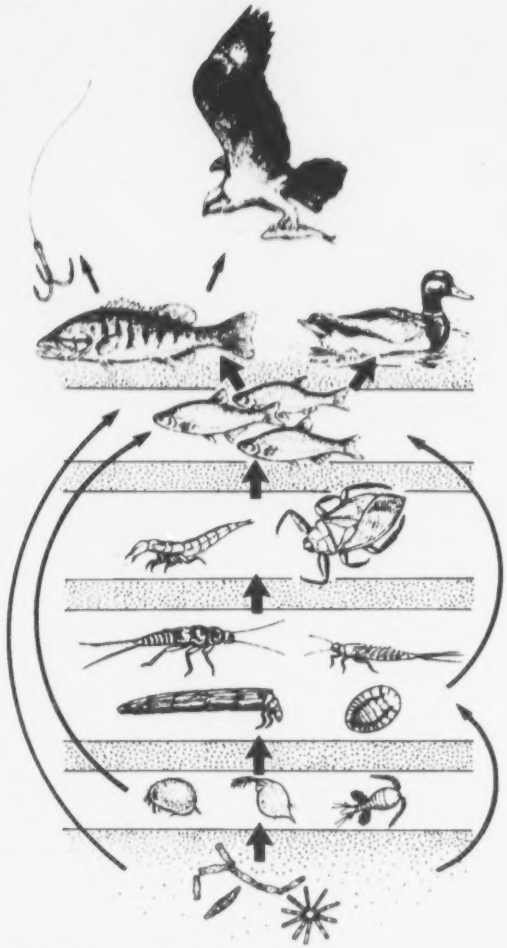
If there are many connections at each level of the food web, the web is strong and less likely to be damaged by disruptions in the environment. For an analogy, consider a structure made of children's building blocks. If the structure is made of many blocks at each level, it is less likely to collapse when one block is removed. If the structure is made of just a few vertical blocks, the building will collapse when one block is pulled out.

In this activity, you will give each member of your group a work sheet with pictures of many animals that are common to aquatic habitats such as the ponds and steams they have sampled. They will use their experiences (and knowledge) to construct a food web that is as realistic and also as strong as possible. Remember, the strength of a food web lies in the number of relationships that exist between organisms.

To help your group make some of the connections, several of the animals illustrated on the activity work sheet have the food they eat in their mouths.



Removing one block causes the structure on the top to topple. A structure made of many blocks (bottom) is stronger and not as likely to collapse when one block is removed.



In a food web, organisms are linked together by the food they eat.

What You'll Need

- a large blank sheet of paper for each group member
- copies of the activity work sheet for each group member (in folder)
- scissors
- masking tape or cellophane tape
- pens or colored markers

What to Do

1. Have the group members cut out the organisms illustrated on their activity work sheets.

2. Ask them each to arrange the pictures in a realistic order on a large sheet of paper. For example, plants at the bottom, plant eaters (herbivores) on the next level, predators on the next level, and larger predators at the top.

3. After they decide where everything should be placed, have them tape each picture onto their sheet of paper.

4. Ask them to draw arrows connecting each organism to the food it eats. For example, arrows would go from the algae to the mayfly and from the large fish to the fish hook. Some arrows may skip between levels of the food web; for example, mayflies can be eaten by stoneflies (the next level) and also by trout (two levels up).

5. Have each member share their food web with the whole group. How does one food web differ from another? Why?

Profiles of Common Aquatic Invertebrates

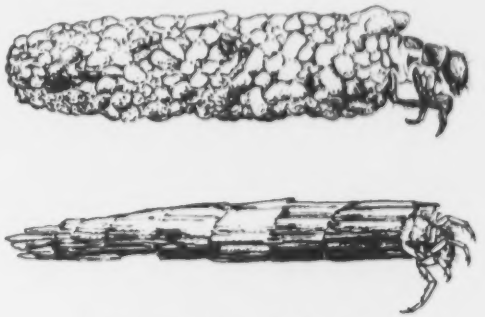
This section describes the common orders of invertebrates you and your group are likely to find on your pond and stream safaris. If you become especially interested in a particular aquatic invertebrate, this section will give you background information that you may not gather in one or two observations alone.

There are many diverse aquatic organisms to discover. Observation is the best tool that you and the youth in your group can use to learn more. Because such a wide variety of life inhabits streams and the shallow areas of ponds, no one aquatic exploration will be exactly like another.

You will begin to recognize familiar creatures in your samples; but because populations of invertebrates are always changing—depending on the season, time of day, stage in the organism's development, and natural and human-made disturbances—different creatures will dominate your samples at different times. If you and your group sample a body of water over a period of weeks or months, you can record these changes and, through your own observations, gain a better understanding of the aquatic world.

Caddisfly (Order: Trichoptera)

Caddisfly larvae are soft bodied and look very much like small caterpillars. Caddisfly larvae are unique, as well as easy to identify, because most build and live in tubelike cases made out of twigs, leaves, pond grasses, small pebbles, or small grains of sand. Caddisfly larvae glue the cases together with a sticky silk that they spin from their mouths. Some larvae make their cases entirely from this material.



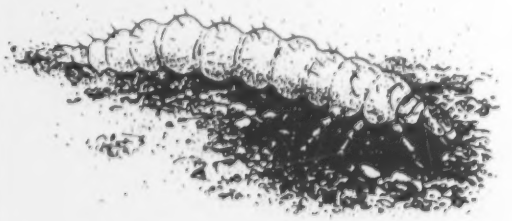
Two types of caddisfly larvae

The cases serve several purposes. Most importantly, they protect the soft larvae from predators. They also help camouflage the larvae. In addition, a case made with pebbles adds extra weight to the caddisfly, preventing it from being swept downstream.

Other types of caddisflies do not build cases but live freely in the water, usually where the current is not strong.

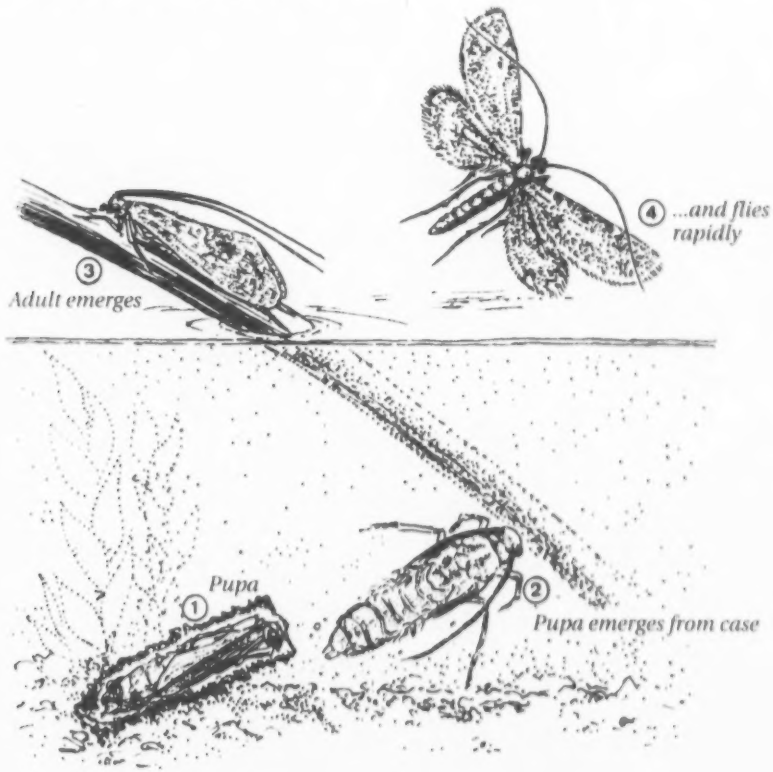
Caddisfly larvae can be found in both still ponds and flowing streams. Caddisfly species that live in streams generally require higher levels of oxygen dissolved in the water than do species that live in ponds.

Different species of caddisfly larvae have different feeding habits. Many species eat dead leaves and very small dead animals, often by filter feeding. Others eat plants such as algae, and still others are predators, which means they eat living creatures.



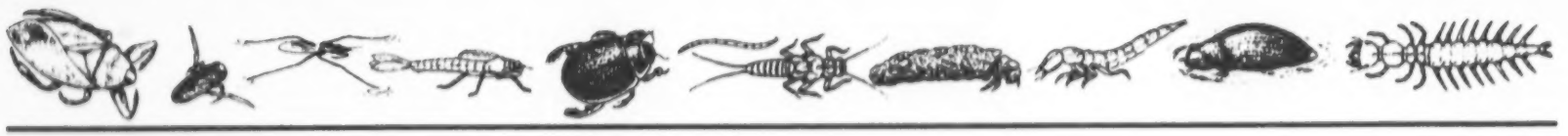
A predatory, caseless caddisfly larva (family Rhyacophilidae)

The caddisfly larva molts about five times. As it gets bigger and fatter, its skin becomes too tight. Like a snake, it sheds the skin that is too small. Some species rebuild their cases after each molt. When the caddisfly larva is ready to become an adult, it seals itself inside its case. At this stage the larva becomes a pupa. Over a period of days or weeks, the pupa rearranges its body inside the case. When the caddisfly pupa emerges, it is ready to become a winged adult. Caddisfly adults live for about two months and mate during this time. Females lay their eggs along the water's edge.



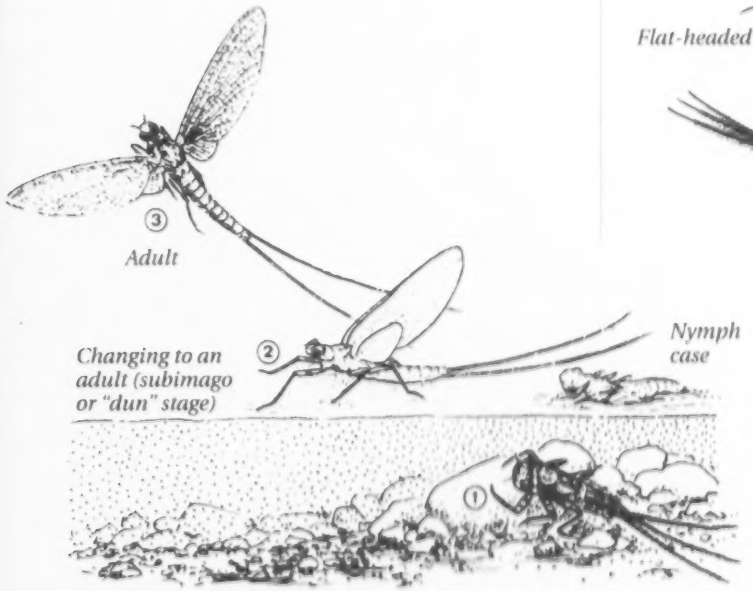
Immature caddisflies change from pupae to adults.

Caddisfly larvae are eaten by a number of fish and therefore are very important in aquatic food webs. When the caddisfly pupa emerges from its case, it swims through the water to the surface, where it undergoes a final molt. It splits down its back, spreads its wings, and flies off as an adult. As the pupa swims to the surface, it is very vulnerable because it has neither its protective case nor wings to fly away from predators. Fish, knowing an easy meal, feed readily on emerging caddisfly pupae. Fly-fishing enthusiasts have found that tied flies that imitate caddisfly pupae are highly attractive to fish.



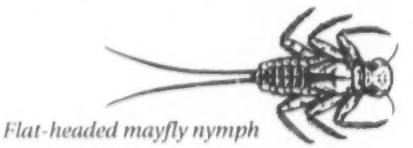
Mayflies (Order: Ephemeroptera)

Mayflies were around when dinosaurs lived on earth. Except for becoming smaller, they have changed little in the past 300 million years. Today, most mayfly nymphs live in fresh, running water. The approximately 700 species of mayflies in North America are a major part of the diets of fish that live in streams, ponds, and lakes.



Mayfly nymphs change into adults.

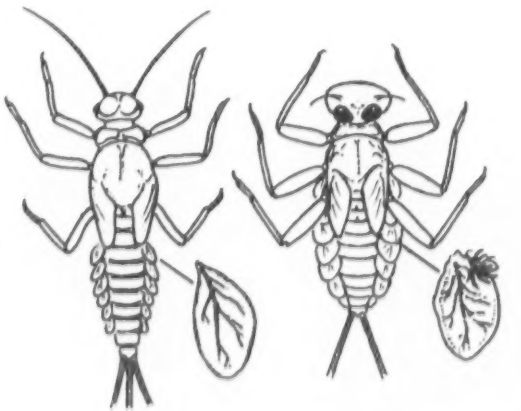
You can find mayfly nymphs hiding under and on submerged rocks, burrowing in the silt, and swimming in the water. Mayflies that live on and under rocks are well adapted to that environment; they are often very flat. Swimming mayflies, however, have a streamlined shape, much like that of a small minnow.



Flat-headed mayfly nymph

Hump-backed mayfly nymph

One way to distinguish a mayfly nymph from other nymphs is to look for gills. Seven pairs of gills, located along the length of the abdomen, help the mayfly nymph absorb oxygen from the water. Gill shapes vary from species to species. Some gills are short, some are long and tapered like leaves, and others are forked. Mayflies wave their gills to create a current, which increases the amount of dissolved oxygen passing over the gills.



Gills on mayfly nymphs

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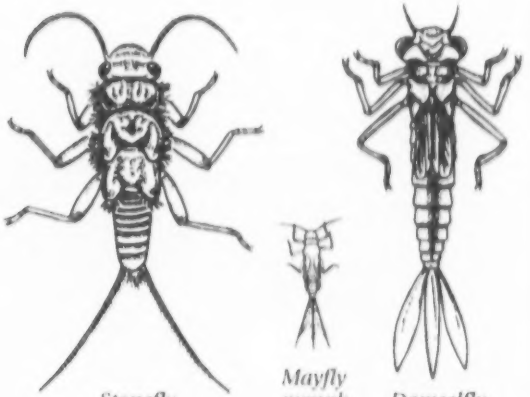
Mayfly nymphs generally have three tails attached to the end of their abdomen. The tails help the mayfly swim. You also can see tails on adult mayflies, trailing behind them as they fly. The presence or lack of three tails, however, cannot be used to identify a mayfly. Some species have two tails, and some mayflies may have lost a tail. To identify a nymph accurately, always check for gills along the sides of the abdomen.



Stonefly nymph

Mayfly nymph

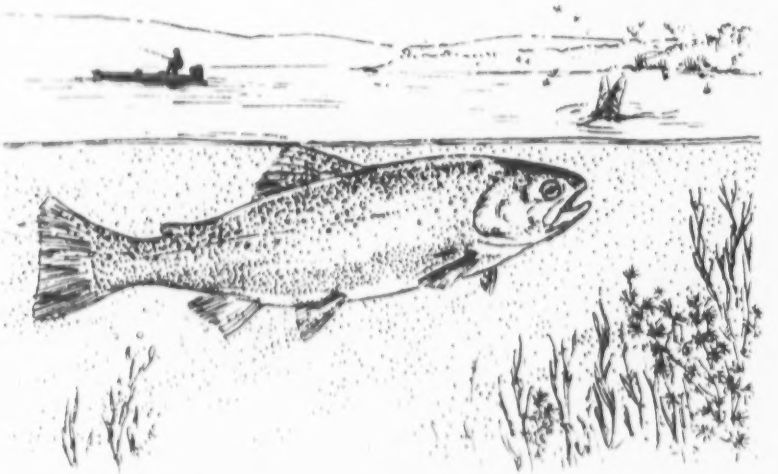
Damselfly nymph

Remember to check for gills before you identify an insect nymph as a mayfly. Stoneflies have two tails, but no gills down the sides of their abdomen. Damselfly nymphs have three tail-like appendages at the end of their abdomen, but no gills along the sides of their body.

Mayfly nymphs have certain adult characteristics. Wing pads are visible, for example. The older the mayfly gets, the larger and darker the wing pads get. Also, their legs are fully developed, even in early nymphal stages.

The mayfly belongs to the insect order Ephemeroptera. This name tells us something about its adult life. *Ephemeral* means short-lived. Although mayfly nymphs live for about a year, adult mayflies live only three days at the most. Their sole purpose as adults is to mate and lay eggs, adding to the next generation of mayflies. Sometimes thousands of mayflies emerge as adults at the same time, and then they all die within hours of each other. Dead mayflies on shores, roads, and bridges can form into piles several inches thick. Although mayfly nymphs eat live and decaying plants, adults do not have the ability to eat.

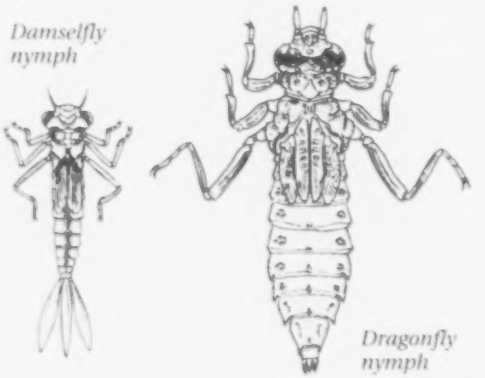
Imitations of mayfly nymphs and adults are popular ties for fly-fishing because mayflies are a common food of trout. Mayflies are especially vulnerable to being eaten by trout as the nymphs emerge from the water's surface, as the egg-laying females rest on the top of the water, and just after the females die following egg laying.



Dragonflies and Damselflies (Order: Odonata)

Another very ancient order of insects includes dragonflies and damselflies. Their ancestors ruled the air 300 million years ago. With wingspans of up to 3 feet (1 meter), they were the most formidable flying predators around. Flying dinosaurs and birds had not yet evolved. Today, dragonflies and damselflies are much smaller, but they are still effective predators, both as nymphs and as adults.

Dragonfly and damselfly nymphs are found almost exclusively in ponds, marshes, and along lake shores, although you may see a few in slow-moving portions of streams. Equipped with huge compound eyes, these insects have nearly a 360-degree view of the world around them. This range of vision helps them strike at prey.



The lower "lip" of the dragonfly or damselfly nymph is also adapted to predation. It is hinged in two places and has grasping pincers on the end. A nymph can snatch prey in just a few hundredths of a second. It then folds its lip back in and stuffs the food into its mouth.

The hinged lower lip of a dragonfly nymph

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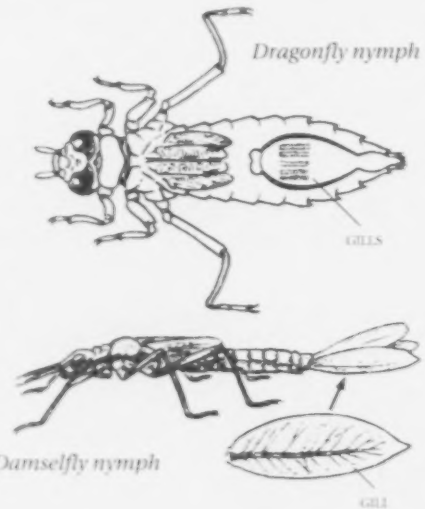
The color of dragonfly and damselfly nymphs is also well suited for stalking prey. Camouflaged by their brown or green bodies and often covered with algae, they blend into the background as they cling to a plant or lie waiting in the mud at the bottom of a pond. Dragonfly and damselfly nymphs eat a variety of foods, including mollusks, insects, crustaceans, worms, and sometimes even small fish. In fish hatcheries, dragonflies can be an economic threat.

As adults, dragonflies and damselflies are equally good predators. Dragonflies commonly fly at about 25 miles (40 km) per hour, but they are capable of spurts of speed of up to 75 miles (120 km) per hour. A dragonfly, with its sharp eyesight, can capture a flying insect on the wing. The legs reach down forming a basket to capture the prey. The dragonfly then eats its meal as it flies.

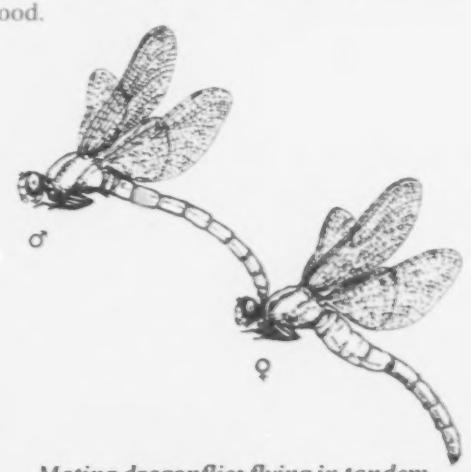
Nymphs of dragonflies and damselflies are sometimes the prey of fish. Some dragonfly nymphs are called bass bugs by anglers and are used as bait. Adults are the prey of birds and frogs.

Although both use gills, dragonflies and damselflies obtain oxygen in different ways. The damselfly has three leaflike gills at the end of its abdomen. The dragonfly's gills are inside its body. To get water to pass across the gills, the dragonfly nymph draws water in through an opening at the end of its abdomen. As water passes over the gills, the gills absorb the dissolved oxygen. Then the nymph forces the used water out of its body. The expelled water propels the dragonfly nymph through the water.



The body of a dragonfly nymph can be long and torpedo-shaped or round and spiderlike. As you would expect, the torpedo-shaped nymphs move through water much more swiftly than do the spiderlike nymphs, which creep along the bottom on their long legs. Damselfly nymphs are generally long, thin, and more delicate. Although in prehistoric times dragonfly and damselfly nymphs sometimes exceeded 1 foot (30 cm) in length, now they are seldom more than 2 inches (5 cm) long.

When adult dragonflies and damselflies mate, the male grasps the female behind her head with a pair of pincers at the end of its abdomen, and the two fly in tandem for many hours. The males are territorial and can reach inside the female to clean out sperm deposited by other males, increasing their own chance of fatherhood.



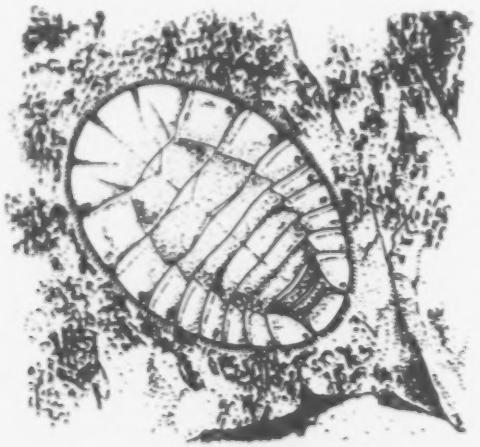
Mating dragonflies flying in tandem

Beetles (Order: Coleoptera)

Beetles are a large order of insects. In North America, more than 1,000 beetle species spend at least part of their lives in water. Some, such as whirligig beetles and predaceous diving beetles, live in water or on the water's surface for almost their entire lives, although they can fly from one pond or stream to another. Others, such as the water penny, are aquatic as larvae and then terrestrial, or land dwelling, as adults.

Beetles have adapted to live in many different environments. Therefore, unlike caddisfly larvae or mayfly nymphs, which are easily distinguished by key characteristics, beetle larvae have diverse life histories as well as physical characteristics.

Water pennies are adapted to life in cold, fast-running streams. Up to ½ inch (12 mm) in diameter and less than ⅛ inch (3 mm) high, their platelike, streamlined shape protects them from being swept away by the current. Their body shape and color camouflage them from most predators. Water pennies attach themselves to the undersides of rocks, where they are out of sight and difficult to pry loose. It is possible to pick up a rock and not see one until it slowly begins to move. As they move over stones, water pennies graze on microscopic algae and other encrusted material. Water pennies obtain oxygen from the water through small, white, tufty gills behind their third set of legs.



Water penny beetle larva

To become adults, water pennies go through a complete metamorphosis and emerge looking like typical beetles. Although adults don't live in water, they spend much of their time along the shores of streams.

Not all beetle larvae look like the water penny. More than 40 percent of the beetle species in North America are predaceous diving beetles, which are aggressive and even cannibalistic as both larvae (often called water tigers) and adults. They can even eat small fish.

A predaceous diving beetle larva attacking a tadpole

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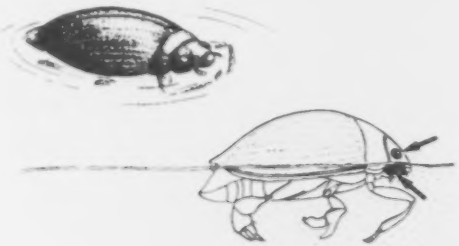
The larvae have mouthparts that can puncture prey and suck out their fluids. Most predaceous diving beetles live in still, fresh water, although some species are found in running water. Predaceous diving beetle larvae are slender and range from 3 inches (70 mm) to ¼ inch (5 mm) in length. Three obvious pairs of legs extend to the side, and the abdomen narrows to almost a point at its end.

Another common group of aquatic beetles are the water scavengers. Depending on the species, water scavenger beetles eat decaying matter or other animals. Adult water scavenger beetles are distinguished from predaceous diving beetles by their behavior. Predaceous diving beetles move their legs in unison when they swim and surface for air tail-first. Water scavenger beetles move their legs alternately and surface for air headfirst. Also, the larvae of water scavenger beetles have wrinkled body surfaces.

Water scavenger beetle adult

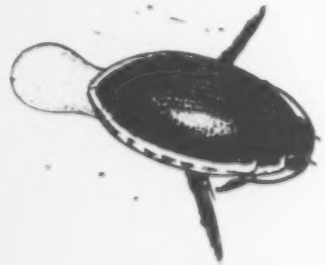
The whirligig beetle spends most of its time on the surface of water. Whirligigs have two pairs of eyes. One pair faces up to see prey on the surface, and the other pair faces down to see prey below.



Whirligig beetles

The adults protect themselves from predators with an odor. Some emit a foul odor, and one type secretes a milky substance that smells like apples. Although the smell of apples might not be offensive to you, it fends off their predators.

Watch an adult aquatic beetle swim. It is much better adapted to life in water than to life on land. Its body is smooth and streamlined. The middle and hind legs often have long swimming hairs, which make the legs look and work like oars. You also may notice a silvery shine to the insect's body or a small silvery bead trailing behind as it swims. This is an air bubble, which the beetle carries with it underwater. Because it carries a supply of oxygen with it when it swims, the beetle doesn't need to surface frequently for air.



The adult diving beetle carries an air bubble underwater.

Stoneflies (Order: Plecoptera)

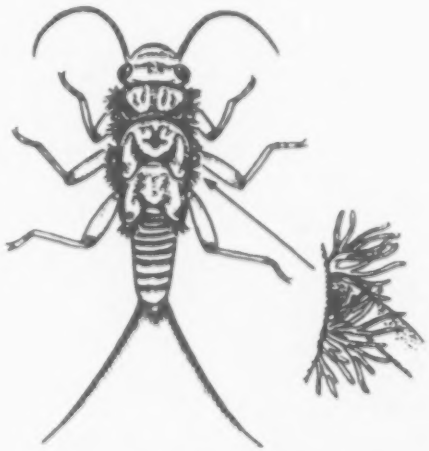
Have you ever seen an insect flying on a mild winter's day or crawling on the snow? Chances are that insect was not confused or sick. It was probably a stonefly.

A stonefly adult crawling on snow

Stonefly nymphs are active all winter long, feeding and moving in icy cold streams. Stoneflies, in fact, do a lot of their growing in water during the winter. Some species even emerge as adults in January or February. In some areas, nymphs of larger stonefly species grow for as many as four years before they become adults.

Stoneflies require high levels of dissolved oxygen. Therefore, they do well in cold stream water because it can hold more oxygen. Some stoneflies also live along the wave-swept shores of large, cold lakes, where the water is also highly oxygenated. Warm water with low levels of dissolved oxygen means death to a stonefly nymph.

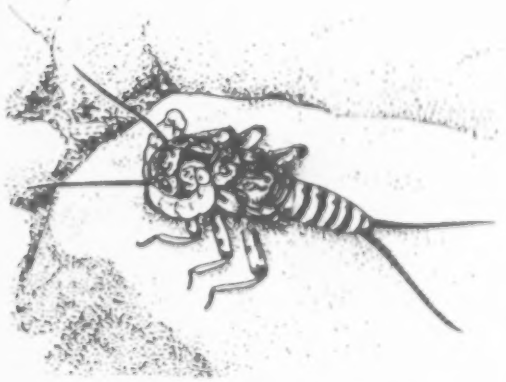
Stonefly nymphs breathe either through the surface of their skin or through single or tufty gills under their legs, in their "armpits." When the oxygen level of water begins to drop, stonefly nymphs do "push-ups," which increase the flow of water (and therefore oxygen) over their body.



Gills on a stonefly nymph (family Perlidae)

The flattened shape of the stonefly nymph is an adaptation for crawling among the stones and gravel of a creek. Stonefly nymphs are not strong swimmers, and the current in open water can be swift. Therefore, most of their foraging takes place along a quiet bottom, not in the open water.

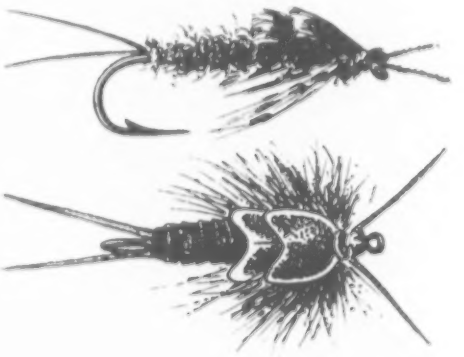
Many stoneflies are active predators and rely on touch, vibrations in the water, or the detection of chemicals released by the prey to locate a meal. A number of stonefly nymphs prefer to eat decaying plants and animals. It is not the decaying matter that the nymphs find so appetizing, however. Scientists believe that the stoneflies are actually going after the protein-rich bacteria and fungi that live on dead plants and animals.



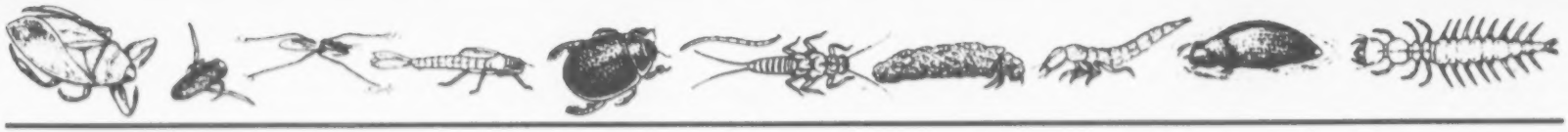
Some stonefly nymphs eat midge larvae.

Stonefly nymphs have very obvious wing pads. Two tails, which remain when the nymph becomes an adult, also help you identify the nymph. When identifying a two-tailed nymph, however, be sure to look also for leaflike gills down both sides of its abdomen. These gills are a distinctive characteristic of the mayfly nymph; if you see them, the nymph is **not** a stonefly. Some mayfly nymphs may have two tails, but their gills are always obvious.

Trout eat stoneflies, and fly-fishing enthusiasts use flies that imitate stonefly nymphs.



A fly-fishing tie that imitates a stonefly nymph



True Bugs (Order: Hemiptera)

True bugs are another type of insect. The word *bug* is often used to describe all insects, but scientists use it to describe one particular group, or order, of insects.

One common feature of all true bugs living in water is a beak, which they use to pierce their prey and then suck out the body's juices. All aquatic true bugs are extremely efficient predators and a very important part of aquatic food webs. They consume many other aquatic insects, including mosquito larvae, and many are a source of food for fish.

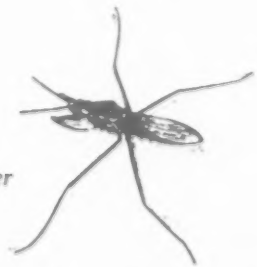
A giant water bug (true bug) with fish prey

If you handle a true bug roughly, it may sting you with its beak. This may be painful for a short time, but since you are so much larger than the insect, there are not enough enzymes in the bite to hurt you badly, unless you have allergies to other insect bites.

The nymphs of aquatic true bugs look very similar to the adults. Only their size and underdeveloped wings distinguish them from the adults.

Aquatic true bugs have adapted to their habitats in a variety of ways. One common true bug that you are likely to see in ponds and calm areas of streams is the water strider. Water striders, sometimes called water spiders because of their long legs, skate across the surface of water, but magically do not fall through. The tiny feet of the water strider have a coating of water repellant wax, which helps keep the body above the surface. The feet are also sense organs that can pick up vibrations of other organisms in the water. The predatory water strider, sensing a meal, can then zip over and eat it. Because water striders are almost always above the water's surface, they get oxygen, as do most land-dwelling insects, through specialized holes in the surface of their skin called spiracles.

Some water strider species live only in the open ocean. No other kind of insect can survive in such a difficult and dangerous environment. Marine water striders congregate in groups in the ocean. It has been suggested that these groups of tiny water striders give the impression of being one large creature, thereby making them less vulnerable to predators.



Water strider

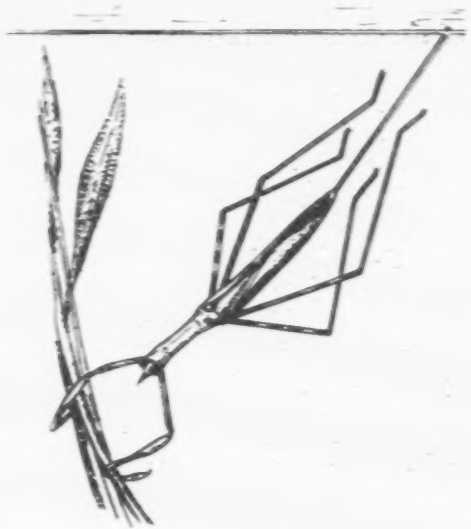
The giant water bug gets oxygen through snorkel-like breathing tubes that extend from its body to the water's surface. By tipping its backside up toward the water's surface, the giant water bug takes in oxygen from the air.

The giant water bug sometimes grows up to 3 inches (7.5 cm) long. It is also known as the toe biter because of the painful bite it can inflict. The bite is only painful to humans, but it can be lethal to smaller animals such as frogs, ducklings, other insects, and fish. A giant water bug was once observed eating a woodpecker! The bite injects a poison into the prey, which causes the internal body parts of the prey to dissolve. In only minutes the giant water bug can suck out the juices.

Another interesting fact about giant water bugs is that the males carry a pad of fertilized eggs on their backs and stroke the eggs to keep a flow of fresh water over them.

Giant water bug

Water scorpions have much longer breathing tubes than do giant water bugs. The water scorpion is often seen quietly hanging from the surface of water with its breathing tube just barely breaking the surface. Water scorpions have excellent camouflage and look much more like sticks than insects. But the bite that the water scorpion can inflict on its prey makes this creature worthy of its name. Water scorpion bites are not as painful to humans, however, as those of the giant water bug.



Water scorpion

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Water boatmen are the largest group of aquatic true bugs in North America. Water boatmen have adapted to many habitats, including running and calm waters and salty intertidal ocean waters. They are better able to tolerate pollution than are most aquatic insects. Water boatmen, as their name implies, are adept swimmers. Their middle and hind legs are covered with long swimming hairs, which increase their surface area and make them act more like paddles than legs. Water boatmen differ from many other true bugs in that they eat not only animals but plants and decaying matter as well.

Water boatman

Another aquatic bug, which looks a lot like a water boatman, is the backswimmer. Backswimmers do just that—they swim on their backs. Unlike many other insects—and fish—which are dark on their backs and sometimes lighter underneath, the backswimmer has a whitish back and a dark underside. This is an adaptation for avoiding predators. Viewed from below, the backswimmer's light back blends in with the glare from daylight above. From above, the dark surface of the bug's underside (facing up) blends in with the dark surface of the water. The backswimmer's legs have swimming hairs similar to those of the water boatman.

Backswimmer

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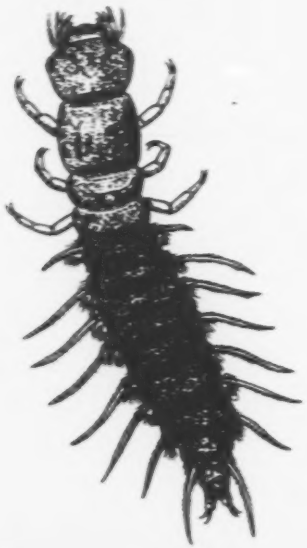
Dobsonflies, Fishflies, Alderflies (Order: Megaloptera)

Dobsonflies, fishflies, and alderflies are members of the same insect order and are important in aquatic food webs. All have an aquatic larval stage and then emerge one to three years later as land-dwelling adults, which live only a few days. They are large (looking a lot like a character in a science fiction movie), predaceous, and sometimes even cannibalistic. The larvae of dobsonflies, or hellgrammites, are well known to anglers. They are good bait for fish because they are so large and lively.



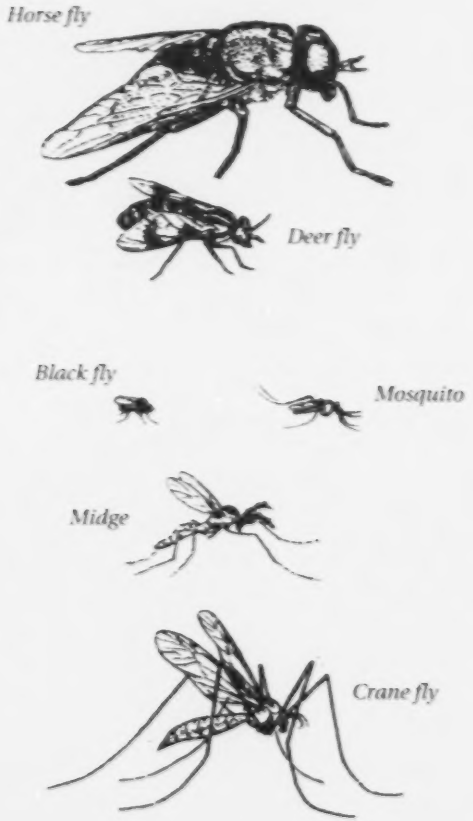
Hellgrammite (dobsonfly larva)

The larvae of these insects are distinguished by their stout body shape and the pointed filaments along the edge of their abdomen. The abdomen ends with either a single long filament (alderflies) or a pair of short, hooked prolegs (fishflies and dobsonflies). The larvae absorb oxygen through the surface of their bodies or through gill tufts along the sides of their abdomen.

Dobsonflies, fishflies, and alderflies are predators. Their diet consists mainly of other stream dwellers such as caddisflies and black flies, and they possess powerful chewing mouthparts. Adult male dobsonflies have extremely long, tusklike mouthparts, which are used for self-defense and in courtship. As ferocious as the larvae are, they also are very shy. You are much more likely to see the larvae of mayflies or stoneflies crawling in streams than you are to see these larvae.

Flies (Order: Diptera)

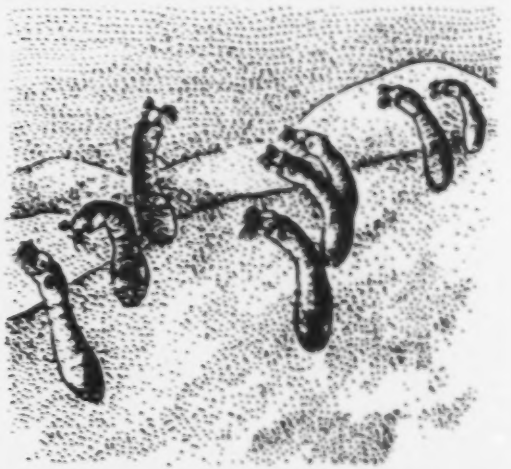
Not many people realize that nearly 3,500 species of flies begin their lives in water. These include black flies, mosquitos, horse flies, deer flies, crane flies, and midges.



100

Black fly larvae are usually found in the cool headwaters of streams. In late spring black fly larvae become adults. The female adults need a blood meal to nourish them as they prepare to lay eggs, and this is when black flies become such vicious biters. You have probably encountered these pests if you have ever camped or hiked in the mountains during May or June.

Adult black flies lay their eggs in the rapids of streams during midsummer, when the stream water is warmest. You probably won't find too many black fly larvae in streams in late summer because the eggs remain dormant (do not develop or change) until the water cools.



Black fly larvae attach to rocks in cool streams.

Cool, flowing water is best for the growth and survival of black fly larvae because it has high levels of dissolved oxygen and carries food particles to the larvae. Black fly larvae do not swim. They attach themselves to the rocky bottom of a stream by small hooks at the end of their abdomen. First the black fly larva spins a small pad of sticky silk that affixes it to a rock. Then the larva's hooks grab onto the pad. If a larva is knocked off a rock, it can often use the silk as a lifeline and reel itself back in. Sometimes you may see rows and rows of tiny black fly larvae attached to the bottom of a stream, lined up so they are oriented to the flow of food and oxygen. Black fly larvae are a good source of food for trout and other fish that live in cool streams.

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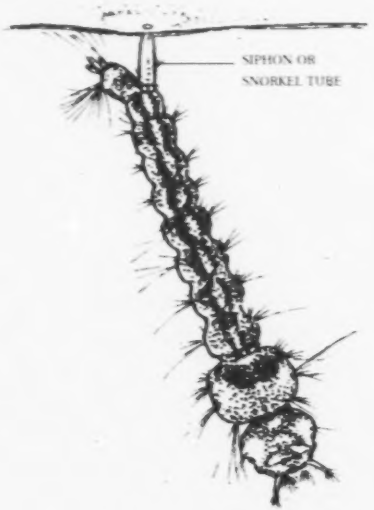
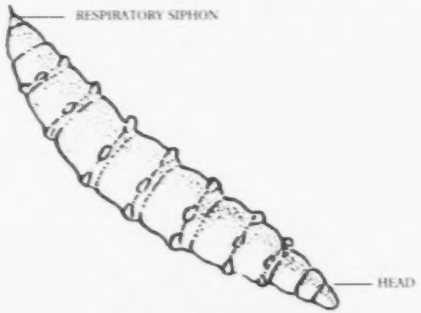
Mosquitos are found in a much different habitat. When you think about mosquitos, does the image of a swamp come to mind? Mosquito larvae live in still or stagnant water. They are commonly found in ponds, marshes, swamps, and lakes. Unlike black fly larvae, mosquito larvae do not require high levels of dissolved oxygen. This is because mosquito larvae have a snorkel-like breathing tube that pokes through the water's surface and draws in oxygen from the air. Because of this adaptation, mosquito larvae can live in polluted water, which has low levels of dissolved oxygen.



Mosquito larva

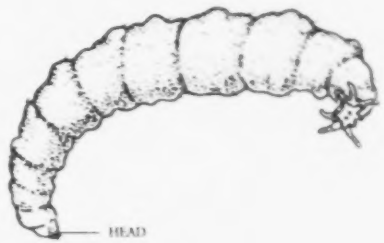
Another fly larva that is very tolerant of polluted water is the rat-tailed maggot (called "mousies" by anglers). This larva has a long, snorkel-like tail that draws in oxygen from the air. As adults, rat-tailed maggots are known as hover flies.

The larvae of horse flies and deer flies, two other biting flies, are predators. They are stout and cigar-shaped and live in ponds and along the edges of streams. The end of their abdomen narrows to a pointed siphon through which they breathe air from above the water's surface.



Horse fly larva

In the summer, you are likely to see insects that look like long-legged giant mosquitos lightly bouncing along the walls of your house or around an outdoor light. These insects are not mosquitos and they do not bite as adults. They are called crane flies, and many begin their lives on stream bottoms. Some species live in tall vegetation in ponds and lakes, and others inhabit damp soils and even compost piles. As larvae, most crane flies eat a range of foods, from wood pulp to other insects.



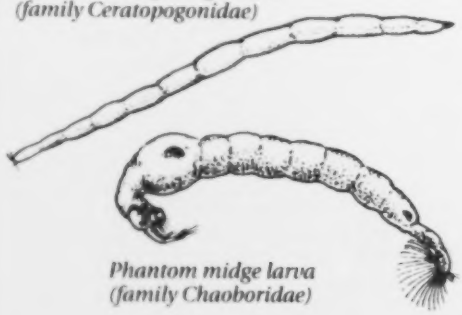
Crane fly larva

The head of the crane fly larva is buried within the first segment of its body and often is not visible. The larvae are plump, long, and generally cylindrical. Some have a translucent, rainbowlike sheen to their bodies. Fingerlike extensions protrude from the end of the abdomen and within these are spiracles, or breathing holes. The larvae move to the water's surface and take in oxygen from the air through the spiracles.

Live crane fly larvae are tantalizing bait for trout, bass, and other game fish. People who tie flies for fly-fishing often create flies to resemble these larvae.

No-see-ums and midge larvae, which include bloodworms, are slender and cylindrical and usually not much longer than ½ inch (12 mm). No-see-um larvae swim freely in water, whereas large numbers of midge larvae live in the bottom sediments of lakes, ponds, and streams. There they feed on smaller larvae, microorganisms, and decaying matter. The feces of midge larvae create an oozy bottom layer in ponds. In prehistoric times, similar midge ooze was responsible for producing oil shale formations.

Punky or biting midge larva (family Ceratopogonidae)



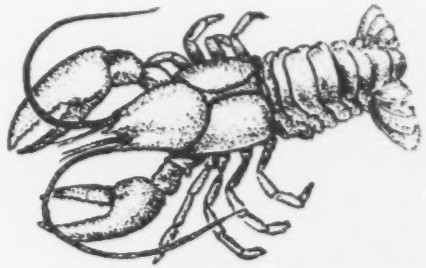
Phantom midge larva (family Chaoboridae)

Depending on the species, midges get their oxygen from the air through breathing tubes or, in the case of the midge bloodworm, store oxygen in their body fluid with the aid of a compound similar to hemoglobin, which we have in our blood. Midges are an important link in food webs, providing nourishment for many fish. Fly-fishing enthusiasts catch large fish using flies that imitate very small midge larvae.

Crustaceans (Class: Crustacea)

There are invertebrates that are not insects that live in streams, lakes, ponds, and rivers. They are called crustaceans. One big difference between insects and crustaceans is that insects have six legs and crustaceans usually have eight or more. Also, crustaceans never develop wings, so they are not able to fly.

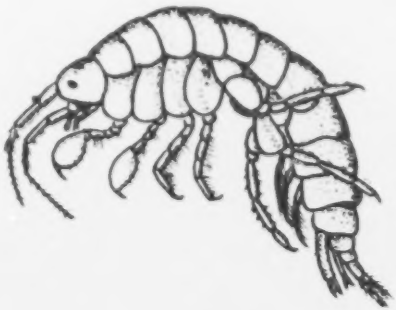
A common crustacean is the crayfish. Crayfish, which live in streams, look more like small lobsters than insects. Count the legs of the crayfish and note their different shapes and sizes. Crayfish are decapods, which means they have ten legs. Crayfish live on the bottom of streams and ponds and during the day stay hidden under rocks or in their burrows. A crayfish moves quickly backwards if it is threatened. If you pick one up, grasp it firmly behind its last set of legs, keeping your fingers clear of the large front pincers. Crayfish eat dead vegetation as well as other small invertebrates.



Crayfish

Another common crustacean is the scud (sideswimmer or amphipod). Scuds are small, about ⅜ inch (1 cm) long, and are found in unpolluted water. Their bodies are flattened from side to side. As their second name implies, scuds zip through water on their sides. You can find scuds in ponds, lakes, streams, rivers, and springs. Some water is teaming with scuds.

Scuds eat dead and decaying matter. As both a scavenger and a source of food for fish, scuds are an important part of the aquatic food web. Sometimes you may collect a scud that has a larger scud riding piggyback on it. These scuds are actually mating, and they may swim together like this for up to a week.



Scud

A third common aquatic crustacean is the aquatic sowbug, or isopod. Sowbugs have relatives—the pillbugs—that live on land. Aquatic sowbugs are commonly found in streams, but they also may live in ponds. Like scuds, they eat dead and decaying matter. Unlike scuds, they are not lively swimmers and spend most of their time in the water under stones or in decaying plants and leaves.

Aquatic sowbug

Glossary

abdomen: The last of the three sections of an insect's body. The first section is the head and the middle section is called the thorax. The insect's six legs are attached to the thorax. Claws or tail-like filaments are often attached to the end of the abdomen.

adaptation: An acquired or evolved trait that makes an animal more fit to live in a particular situation or habitat.

aquatic: Having to do with water.

arachnid: The group of invertebrates whose members are characterized by a spherical body and eight legs. Examples of arachnids are water spiders and mites.

biological indicator: A living thing whose presence or absence tells something about the quality of the environment.

biomonitoring: Assessing the water quality of a pond or stream by sampling the invertebrate population living there. Water of high quality supports insects that are sensitive to pollutants. These insects are not found in waters that are polluted.

blooms: Excessive growth of algae.

complete metamorphosis: The major change that occurs when an insect larva becomes an adult: wings develop; legs appear or lengthen; the soft, wormlike body changes shape and hardens; and the insect becomes sexually active. Beetles, flies, mosquitos, crane flies, caddisflies, and midges all have larval stages.

compound eye: A type of eye common to dragonflies, damselflies, bees, and flies. The surface of the eye has many facets like a diamond. This allows the animal to see many images of the object being viewed. Humans have simple eyes and see just one image of an object.

crustacean: One of the group of invertebrates whose members are characterized by having more than eight legs and a hard shell. Examples of aquatic crustaceans are crayfish and scuds.

detritivore: An animal that feeds on dead and decaying matter.

dissolved oxygen: Molecules of oxygen that are present in water.

dormant: Not active.

emerge: In the life cycle of an aquatic insect, the act of changing from an immature form into an adult. The emerging insect sheds its outer skin and flies from its aquatic habitat.

filter feed: To strain small particles of food (both plant and animal matter) from water. Aquatic insects use fine hairs on their bodies or construct a web or mesh to strain water for food.

food web: The complex association of plants and animals in nature whereby organisms are interconnected because they are sources of food for one another. At the base of the food web are green plants and bacteria, which supply food for small animals. Larger animals eat smaller animals as well as plants. In addition, detritivores recycle nutrients by breaking down decaying plants and animals.

gill: A thin, often leaflike portion of an insect's body that facilitates the transfer of dissolved oxygen from the water for use by the insect.

habitat: A specific environment in which a creature lives. For example, the habitat of a stonefly nymph is the cool riffle of a stream; the habitat of a bluegill is a farm pond.

hatch: When numerous (sometimes thousands) of insects emerge simultaneously as adults. Mayflies especially are known for their large hatches.

herbivore: An animal that eats plants.

incomplete metamorphosis: The change that occurs when an insect nymph becomes an adult. Certain adult features such as wing pads and developed legs are evident on the nymph before it changes to an adult. Mayflies, stoneflies, dragonflies, damselflies, and true bugs are all nymphs before they become adults.

larva: The immature form of certain insects, such as beetles, flies, mosquitos, crane flies, caddisflies, and midges. Larvae go through complete metamorphosis to become adults.

macroinvertebrates: Animals without backbones (insects, crustaceans, and arachnids) that are large enough to be seen without a microscope.

mandibles: Mouthparts on insects that are located beneath the antennae. Although usually used for feeding, mandibles have been adapted for other purposes such as courtship.

metamorphosis: The physical change that occurs when an immature insect becomes an adult.

microorganisms: Animals that are so small it is necessary to view them through a microscope. Bacteria are examples of microorganisms.

molt: In insects, the shedding of the outer "skin" layer when the insect has grown too large for its encasement. The insect forms a new outer layer beneath the old one prior to the molt.

nymph: The immature form of certain insects, such as mayflies, stoneflies, and true bugs. Nymphs go through incomplete metamorphosis to become adults.

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omnivore: An animal that eats a variety of foods, including plants, animals, and decaying matter.

order: A category used by scientists to classify animals according to similar characteristics. With insects, for example, stoneflies are in one order and mayflies are in another.

photosynthesis: The process by which plants convert sunlight into food (sugars).

plankton: Microscopic plants and animals that drift with the currents in streams and lakes. Some insects and fish feed on plankton.

predaceous: Eats other living animals.

predator: An animal that eats other living animals.

pupa: A phase in complete metamorphosis that occurs between the larval stage and the adult stage.

rectal chamber: A cavity at the far end of the dragonfly's abdomen that contains the insect's gills.

scavenger: An animal that eats dead and decaying matter.

species: The most specific category used by scientists to classify animals. For example, within the insect order of true bugs there are many different species. The giant water bug and the water strider are each a species of the true bugs.

spiracles: Small openings on the surface of a land-dwelling insect that allow oxygen to pass into the insect's body.

terrestrial: Living on land.

true bug: An order of insects whose members are characterized by a piercing beak that is used to kill and eat other animals. Examples of true bugs are giant water bugs, water boatmen, water striders, and water scorpions.

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Appendix

Building Sampling Equipment

White Observation Tray*

The invertebrates collected on your pond and stream safaris are likely to be dark in color. Their coloration helps camouflage them against the dark bottoms of the ponds and streams. Although this protects them from predators, it keeps you from seeing them clearly in their natural settings. To observe the aquatic creatures your group collects, you will need white pans or light-colored containers.

Luckily, many types of viewing pans are available. Although it is possible to purchase shallow white enamel pans from a scientific supply company, there are less expensive alternatives: keep an eye out at garage sales for white pans; use white plastic dish tubs or shallow food storage containers; or place clear plastic containers on white paper to get a white background.

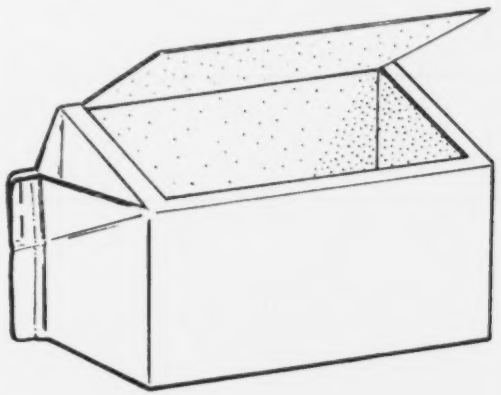
As another alternative, your group can make their own white observation trays—*and* reuse a household throwaway item.

What You'll Need

- a half-gallon milk carton
- a stapler
- scissors or a knife

What to Do

1. Clean the milk carton thoroughly.
2. Staple the pouring spout closed.
3. Cut out the wall of the carton on the same side as the stapled pouring spout.



Milk carton observation tray

*Adapted from *Curriculum Guide in Environmental Studies*, Cayuga Nature Center

D-Net*

A common type of net for collecting aquatic insects is a D-net. The net is named for the shape of its metal frame. D-nets are used to collect creatures living on the bottoms of streams and ponds. In streams, place the flat end of the D-net directly on the stream bottom. Holding the net in a stable, upright position, disturb the area just upstream and in front of the net by kicking the rocks and sediment. The creatures on the rocks and in the sediment will let go and drift with the current into the net. In ponds, sweep the D-net through aquatic plants along the banks to collect the creatures normally clinging to the plants or swimming in the water.

What You'll Need

- a 42-by-14-inch (105 cm by 35 cm) piece of fiberglass screening
- a 42-by-2-inch (105 cm by 5 cm) piece of canvas or other heavy fabric
- thread and a needle or a sewing machine
- scissors
- a wire coat hanger
- wire cutters
- a drill with ⅛-inch and ¼-inch bits
- a wooden broom handle or a closet rod
- pliers
- duct tape or a hose clamp large enough to encircle the wooden rod

What to Do

1. Fold the screening in half to get a folded piece that is 21 inches by 14 inches (53 cm by 35 cm). Cut the net as shown in the illustration.

2. Sew the two pieces of screening together along the cut edge as shown.

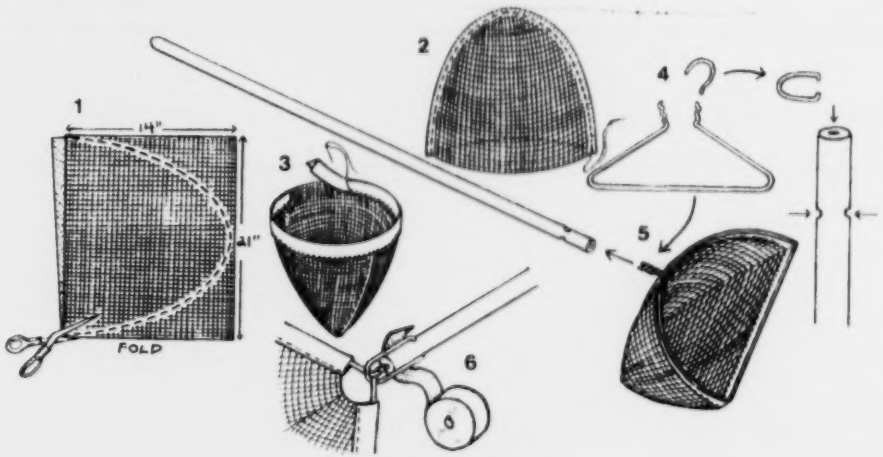
3. Fold the heavy fabric in half along its length and sew it to the net as shown. This is the casing for the frame of the D-net.

4. Untwist the wire coat hanger and cut off the top as shown. Bend the top piece into a U-shape. Drill a ¼-inch hole in the flat end of the rod or broom handle. Drill two shallow ⅛-inch holes in the sides of the broom handle positioned so you can insert the ends of the U-shaped piece of wire.

5. Slip the large piece of wire into the casing, then twist it back together again. Cut the twisted wire stem to a length of about 2 inches. Insert the wire stem into the hole drilled at the end of the broom handle as shown.

6. Secure the net to the broom handle with the U-shaped piece of wire and insert the ends of the wire into the holes along the side of the broom handle as shown. Wrap together tightly with duct tape or fasten a hose clamp over the wire and tighten.

*Adapted from *Homemade Sampling Equipment*, Water Quality Series booklet 2, Tennessee Valley Authority



Building a D-net

Seine

A seine helps you see what creatures are living in the water and on the bottom of a stream or pond. It is best to use a seine with one other person. Seine nets smaller than 36 square feet (3.25 square meters) are quick and easy to build and do not require special permits to use.

What You'll Need

- a rectangular piece of fiberglass netting or other strong open-weave fabric, approximately 3 feet x 4 ½ feet (1 meter x 1½ meters)
- a needle and thread or sewing machine
- two sturdy 1-inch x 2-inch (2.5-cm x 5-cm) pieces of wood, 3 to 4 feet (1 to 1.3 meters) long
- a staple gun or roofing nails and a hammer
- two strips of cardboard, 1 to 2 inches (2.5 to 5 cm) wide

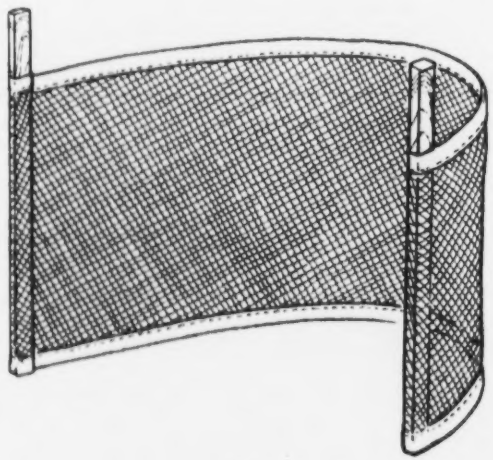
What to Do

1. Hem both long edges of the netting material so it doesn't unravel or tear.

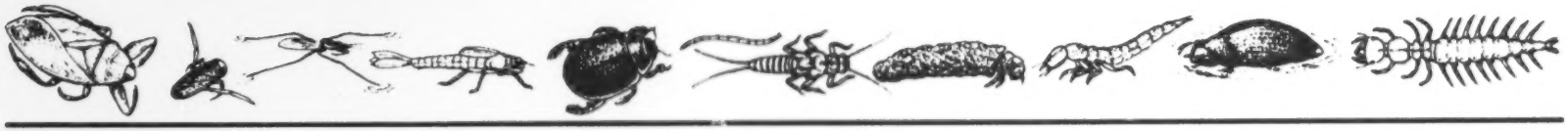
2. Staple each of the short edges of the netting to one of the wood pieces, leaving some space at the top for a handle.

3. Roll each wood piece one wrap inward toward the center of the net to reinforce the connection. Staple or nail the netting again.

4. Staple or nail each piece of cardboard over each wrapped wood piece to keep the netting from pulling through the staples.



Seine net



Resources

Curricula

Curriculum Guide in Environmental Studies, Cayuga Nature Center. 1988. Includes activities related to ponds and streams, insects, plants, and other animals. $30.00 plus tax and shipping.

Contact:
Cayuga Nature Center
1420 Taughannock Boulevard
Ithaca, NY 14850
(607) 273-6260

Field Manual for Water Quality Monitoring, by Mark Mitchell and William Stapp, 1991. $9.95.

Contact:
William Stapp
2050 Delaware
Ann Arbor, MI 48103

Living in Water, an aquatic science curriculum for grades 4 to 6. 1987. $10.00.

Contact:
National Aquarium in Baltimore
Dr. Valerie Chase
Pier 3
501 East Pratt Street
Baltimore, MD 21202

Outdoor Biology Instructional Strategies (OBIS) Pond Guide. 1980. An 18-page booklet about plant and animal identification in ponds. $3.95. Also available: OBIS Ponds and Lakes module and OBIS Streams and Rivers module, $18.95 each; each module has 8 activity cards and includes the pond guide.

Contact:
OBIS
Delta Education
PO Box 915
Hudson, NH 03051
(800) 258-1302

Project Mayfly: Guide to the Determination of Water Pollution in Local Waterways. 1988. About $6.00.

Contact:
Washington Crossing Audubon Society and
National Audubon Society
Mid-Atlantic Regional Office
1104 Fernwood Avenue, #300
Camp Hill, PA 17011
(717) 763-4985

Project WILD Aquatic, developed by the Western Association of Fish and Wildlife Agencies and the Western Regional Environmental Education Council. 1987. An interdisciplinary aquatic education activity guide. Free training workshops and the activity guide are available in New York State through the Department of Environmental Conservation (DEC).

Contact:
Project Wild Aquatic
P.O. Box 18060
Boulder, CO 80308-8060
(303) 444-2390

In New York State, contact:
Project Wild Aquatic
Attn: Department of Environmental Conservation/Frank Knight
50 Wolf Road
Albany, NY 12233
(518) 457-3720

New York State 4-H Sportfishing and Aquatic Resources Education Program (SAREP). 1989. Teaches youth to appreciate the aquatic environment through fishing. Free weekend-long instructor training offered several times a year to New York State residents (fee charged for out-of-state residents). Aquatic ecology, angling ethics, and working with youth in a club setting are emphasized. Leader's manual contains information about fishing in different settings across New York State and supplemental bulletins on fly tying, ice fishing, fish preparation, fish identification, and more.

For additional information contact:
SAREP
108 Fernow Hall
Department of Natural Resources
Cornell University
Ithaca, NY 14853
(607) 255-2814

The Stream Scene—Watersheds, Wildlife, and People, published by the Oregon Aquatic Education Program. 1990. For youth, grades 6 to 12. Includes activities for studying hydrology, the water cycle, riparian areas, water quality, and aquatic organisms. Focus is on West Coast salmon issues. About $15.00.

Contact:
Oregon Department of Fish and Wildlife
P.O. Box 59
Portland, OR 97207

Izaak Walton League of America's Save Our Streams (SOS) Program. Stream biomonitoring and assessment using aquatic invertebrates. The program includes guides, handouts, and other written materials. $6.00. The video *Save Our Streams Water Quality Monitoring* is an excellent description and outline of biomonitoring. $15.00.

Contact:
Izaak Walton League of America's Save Our Streams Program
1401 Wilson Boulevard, Level B
Arlington, VA 22209
(703) 528-1818

Water Worlds. 1988. A 4-H project for youth aged 9 to 12. Includes activities for monitoring the biological and physical aspects of water. (147-L-5-18) $5.35.

Available from:
Resource Center
7 Business and Technology Park
Cornell University
Ithaca, NY 14850
(607) 255-2080

Waterwise: Lessons in Water Resources. 1989. Classroom activities for grades 5 and 6 for studying the water cycle, groundwater and surface water, wastewater treatment, and water purification. (147-WW) $4.00.

Available from:
Resource Center
7 Business and Technology Park
Cornell University
Ithaca, NY 14850
(607) 255-2080

Books

Caduto, Michael. *Pond and Brook.* Englewood Cliffs, N.J.: Prentice-Hall, 1985. $12.95. (Natural history, biology, and geology of aquatic habitats.)

Cvancara, Alan M. *At the Water's Edge: Nature Study in Lakes, Streams, and Ponds.* New York: John Wiley and Sons, 1989. $10.95. (An exploration of freshwater ecology by canoe, kayak, and snorkeling.)

McCafferty, W. Patrick. *Aquatic Entomology.* Boston: Jones and Bartlett Publishers, 1983. $37.50. (An angler's and ecologist's guide to aquatic insects and their relatives.)

Peckarsky, Barbara, Pierre Fraissinet, Marjorie Penton, and Don Conklin. *Freshwater Macroinvertebrates of Northeastern North America.* Ithaca, N.Y.: Cornell University Press, 1990. $26.50, paperback. (Dichotomous key to aquatic invertebrates.)

Reid, George K. *The Golden Guide to Pond Life.* New York: Golden Press, 1987. $3.95. (Full-color guide to reptiles, amphibians, insects, and other plants and animals associated with ponds and lakes.)

Other Publications

Tennessee Valley Authority. *Homemade Sampling Equipment* and *Water Quality Sampling Equipment.* (Two 16-page booklets, free for one-set orders.)

Contact:
Carol A. Davis
311 Broad St.
Chattanooga, TN 37402
(615)751-7338

Other Materials

Bug boxes, about $1.00 per large (1-by-1-by-1-inch) box

Available from:
Museum Products
84 Route 27
Mystic, CT 06355
(800) 395-5400

Aquatic D-net frame, the kind the professionals use. Item no. 10W0620. About $32.00.

Featherweight forceps, for gentle handling of larvae and nymphs. Item no. 14W0520. About $3.00 each.

Both items are available from:
Ward's Natural Science Establishment, Inc.
P.O. Box 92912
Rochester, NY 14692-9012
(800) 962-2660

For groups interested in seriously pursuing water monitoring, contact Ward's Natural Science Establishment, Inc., at the address above and ask about their LaMotte water monitoring test kits, or contact LaMotte directly at (800) 344-3100.

Storm drain stenciling program. Learn how to educate the public about their impact on water pollution by stenciling storm drains with the message "Dump no waste. Drains to (*local body of water*)."

For a free information packet, contact:
Storm Drain Stenciling Program
125 Nassau Hall
SUNY Stony Brook
Stony Brook, NY 11794-5002
(516) 632-8737

Quick Reference Guide to Aquatic Invertebrates

Aquatic Invertebrate	My Distinguishing Characteristics	Where I'm Found	How I Get Oxygen	How I Get Food	Why I'm Special
Sensitive to Pollution					
stonefly nymph	2 tails; 2 sets wing pads	cold running water	through body surface; some small gills; does "pushups" to increase oxygen flow over body	predator or herbivore	streamlined body for crawling on rocks; only tolerates high oxygen levels
mayfly nymph	3 tails, sometimes 2; 1 set wing pads	cool or cold running water	through gills along abdomen	herbivore or scavenger	only tolerates high to medium oxygen levels
caddisfly larva	most species build cases or nets, soft body	cool or cold running water, also ponds	through body surface	filter feeder, herbivore, or predator	builds cases of heavy material (rocks) to avoid being swept away by fast-flowing streams; in ponds, uses grass and plants to make cases
water penny (larva)	round, flat, disklike body	cold running water	through gills on underside	herbivore—grazes on algae	flattened body resists pull of current
Somewhat Tolerant of Pollution					
predaceous diving beetle larva (water tiger)	up to 6 cm long; robust jaws	quiet freshwater	through body surface	voracious predator	special channels in jaws to suck body fluids of prey
whirligig beetle (adult)	black; congregates in schools	surface of quiet water	from atmosphere	predator or scavenger	has two pairs of eyes to see above and below the water's surface; has a type of "radar" to locate objects in the water; secretes a white odorous substance to deter predators
black fly larva	small body; small hooks at end of abdomen attach to rocks	cold running water	through body surface	filter feeder	anchors to rocks with silk; only tolerates medium to high oxygen levels
dragonfly nymph	stout body; grasping jaw	cool still water	dissolved oxygen, through gills in internal body chamber	active predator	clings to vegetation or hides in clumps of dead leaves or sediment
damselfly nymph	3 leaflike gills at end of abdomen	cool still water	through gills at end of abdomen	active predator	clings to vegetation or hides in clumps of dead leaves or sediment
hellgrammite (dobsonfly), alderfly, or fishfly larva	up to 9 cm long	cool slow-moving water	through gills along side of abdomen; some fishflies have breathing tubes	active predator	can swallow prey without chewing
water strider (adult)	skates on water's surface	ponds or still pools of streams	from atmosphere	active predator	can stay on water's surface because feet have small surface area and are water repellent
water boatman (adult)	long swimming hairs on legs	ponds or still pools of streams	from atmosphere, by carrying air bubble from water's surface on body	omnivore, herbivore, or scavenger	has swimming hairs on legs that act as oars
backswimmer (adult)	light-colored underside; swims on back	ponds or still pools of streams	from atmosphere, by carrying air bubble from water's surface on body	predator	swims on back; sleek body shape
crane fly larva	cylindrical body; often has lobes at hind end	bottoms of streams and ponds in algae	from atmosphere through spiracles (openings) at hind end	active predator, herbivore, or omnivore	species that eat woody decaying matter have gut bacteria to digest cellulose
mosquito larva	small body; floats on surface	cool to warm still water	from atmosphere through breathing tube	scavenger—feeds on micro-organisms	swims or dives when disturbed
aquatic sowbug	flattened body, top to bottom; 7 pairs of legs	shallow freshwater, among rocks and dead leaves	through body surface on legs	scavenger—eats decaying matter—or omnivore	male clasps female under it during mating; female then sheds half of exoskeleton, which becomes a case into which fertilized eggs are placed for development
crayfish	5 pairs of legs, first pair often robust; looks like small lobster	under rocks or in burrows in shallow freshwater	through gills under body	scavenger or omnivore	crawls backwards when disturbed; males display some courtship behavior to reduce female aggressiveness
scud	flattened body, side to side; swims on side	bottoms of lakes, streams, or ponds in vegetation or sediment	through gills under body	scavenger or omnivore	male carries female on its back during mating; female then sheds half of exoskeleton, which becomes a case into which fertilized eggs are placed for development
Tolerant of Pollution					
midge larva	small, cylindrical body; sometimes blood red	bottom sediments of lakes, ponds, or streams	through body surface	predator, herbivore, or omnivore	some have substance in blood to hold more oxygen in oxygen-poor environments
rat-tailed maggot (larva)	cylindrical body; tail-like breathing tube	cool to warm water with low oxygen levels	from atmosphere through breathing tube	scavenger—eats decaying matter and sewage	can survive low oxygen levels fatal to most invertebrates
tubifex worms	segmented body; builds a vertical tube from which one end protrudes	polluted or oxygen-poor water	through body surface, but can tolerate water with no oxygen	scavenger—eats decaying matter and sewage	can survive low oxygen levels fatal to most invertebrates

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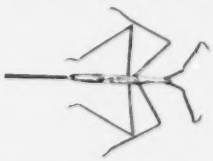
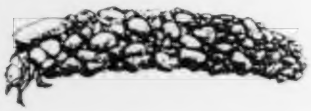
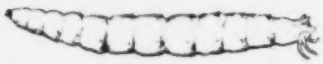
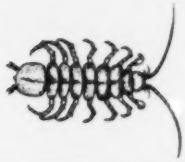
Checklist of Common Aquatic Invertebrates

Aquatic Organism	Number Found in Pond	Number Found in Stream
Dragonfly nymph		
Damselfly nymph		
Water scavenger beetle adult		
Whirligig beetle larva		
Whirligig beetle adult		
Water scorpion (adult) 		
Black fly larva		

Aquatic Organism	Number Found in Pond	Number Found in Stream
Midge larvae		
Water boatman (adult)		
Backswimmer (adult)		
Giant water bug (adult)		
Mayfly nymph		
Stonefly nymph		
Caddisfly larva 		

Aquatic Organism	Number Found in Pond	Number Found in Stream
Crane fly larva 		
Water penny (beetle larva)		
Scud		
Aquatic sowbug 		
Mosquito larva		
Water strider (adult)		
Dobsonfly larva (hellgrammite)		

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Activity 1: Aquatic Safari Record Sheet

Name of collector: _____

Location: _____

Date sampled: _____

Type of habitat (for example, pond, stream, swamp):

Equipment used to sample:

Weather conditions:

Temperature:

Organisms found:

Name or a drawing of invertebrate	How many?

Other organisms found (for example, fish)	How many?

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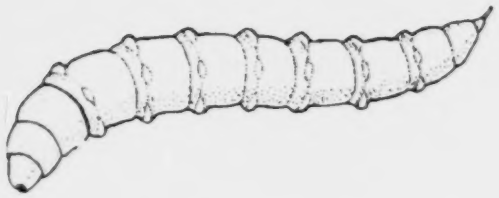
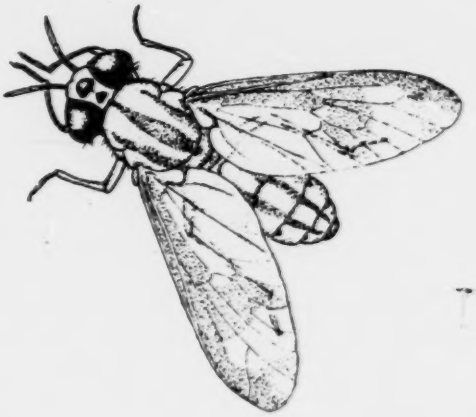
Cards for Activity 3: Immature and Adult Aquatic Organisms

Habitat: pond, stream **Immature**



Habitat of larva: pond, stream **Adult**



Habitat: pond, stream **Immature**

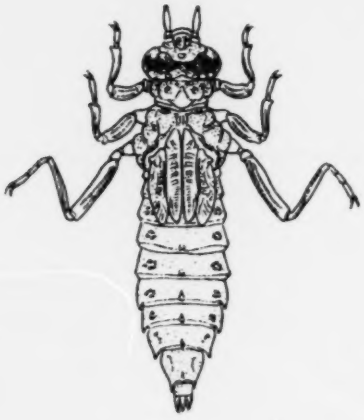
Habitat of larva: pond, stream **Adult**

Habitat: stream **Immature**

Habitat of larva: stream **Adult**

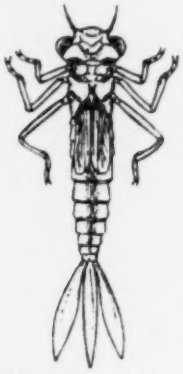
Cards for Activity 3: Immature and Adult Aquatic Organisms

Habitat: pond, slow stream **Immature**

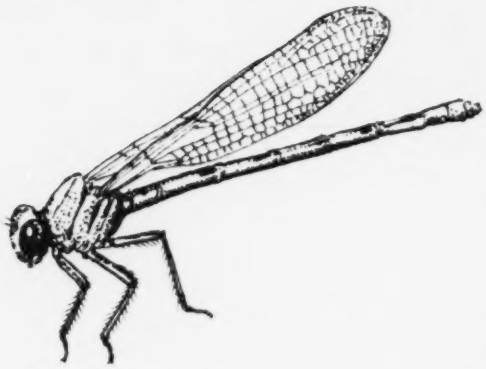


Habitat of nymph: pond, slow stream **Adult**

Habitat: pond, slow stream **Immature**



Habitat of nymph: pond, slow stream **Adult**



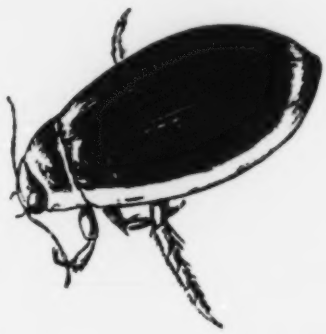
Habitat: pond, stream **Immature**

Habitat of nymph: pond, stream **Adult**

Cards for Activity 3: Immature and Adult Aquatic Organisms

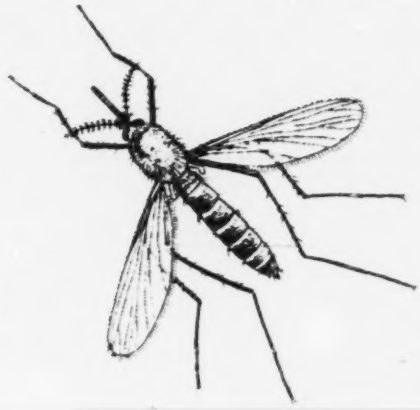
Habitat: pond, stream **Immature**

Habitat of larva: pond, stream **Adult**

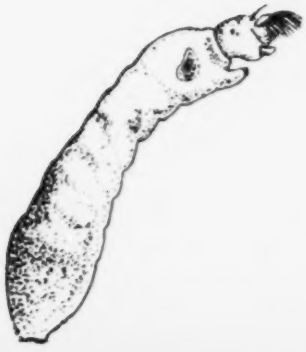


Habitat: pond **Immature**

Habitat of larva: pond **Adult**



Habitat: stream **Immature**



Habitat of larva: stream **Adult**

Cards for Activity 3: Immature and Adult Aquatic Organisms

Habitat: stream, some in ponds **Immature**

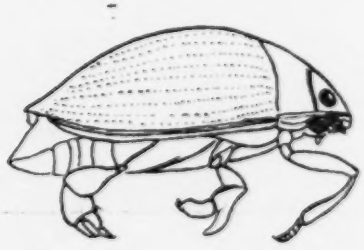
Habitat of larva: stream, some in ponds **Adult**

Habitat: pond **Immature**

Habitat of nymph: pond **Adult**

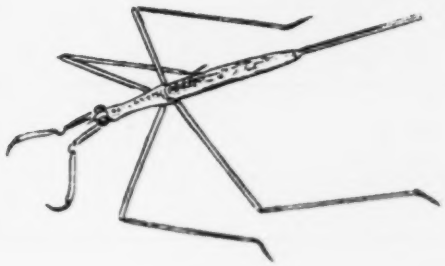
Habitat: pond **Immature**

Habitat of larva: pond **Adult**

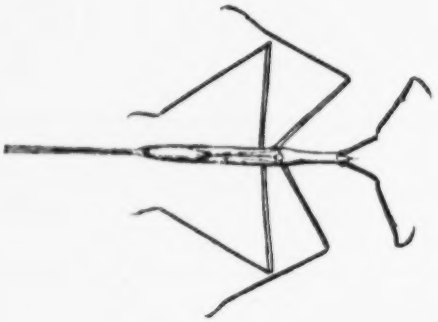


Cards for Activity 3: Immature and Adult Aquatic Organisms

Habitat: pond **Immature**

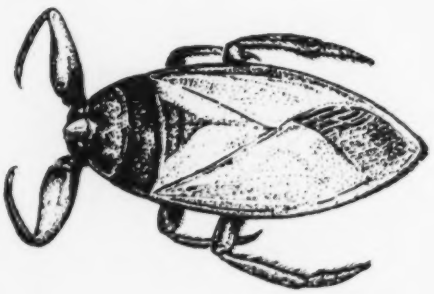


Habitat of nymph: pond **Adult**

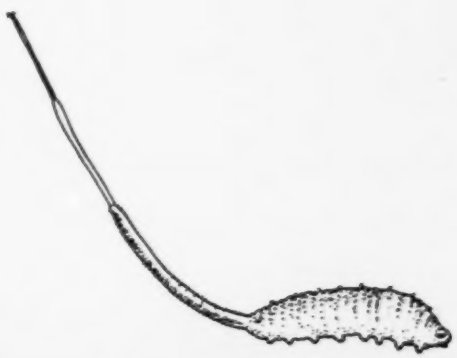


Habitat: pond **Immature**

Habitat of nymph: pond **Adult**



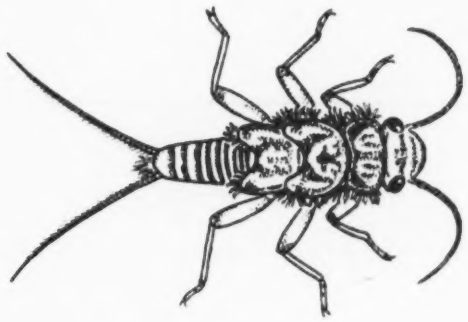
Habitat: pond **Immature**



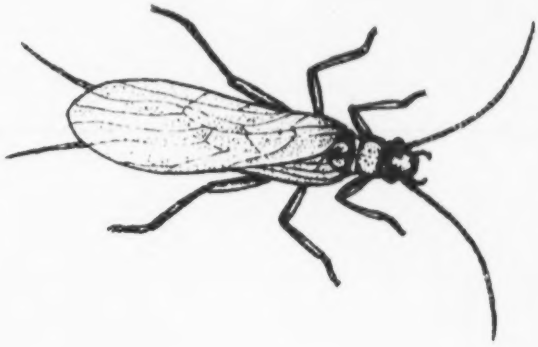
Habitat of larva: pond **Adult**

Cards for Activity 3: Immature and Adult Aquatic Organisms

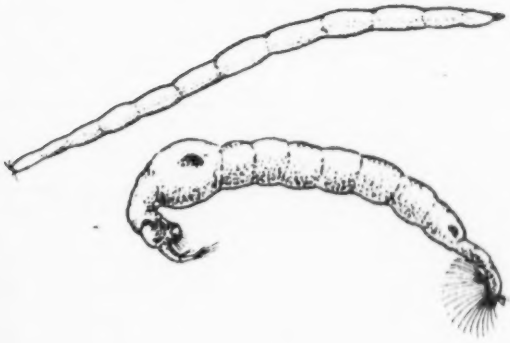
Habitat: stream **Immature**



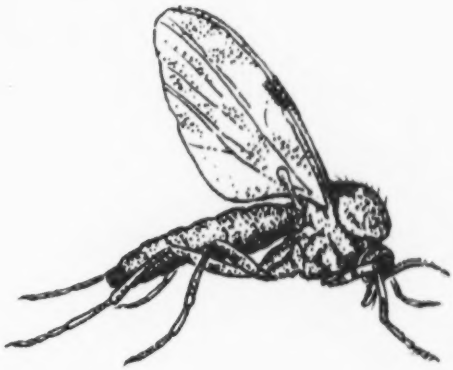
Habitat of nymph: stream **Adult**



Habitat: pond, stream **Immature**

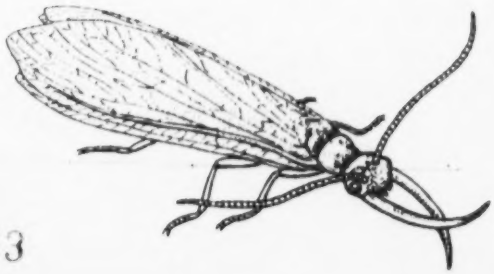


Habitat of larva: pond, stream **Adult**



Habitat: stream **Immature**

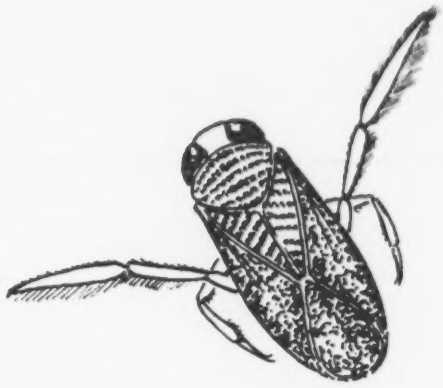
Habitat of larva: stream **Adult**



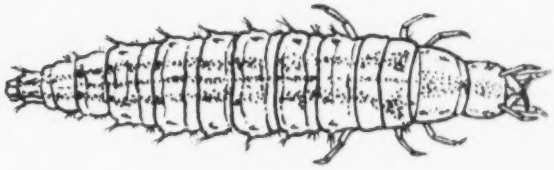
Cards for Activity 3: Immature and Adult Aquatic Organisms

Habitat: pond **Immature**

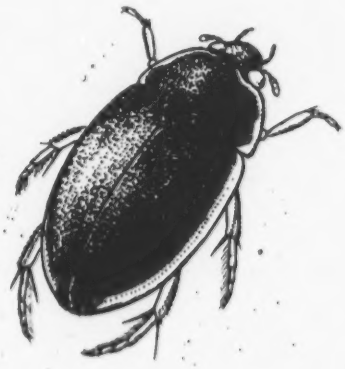
Habitat of nymph: pond **Adult**



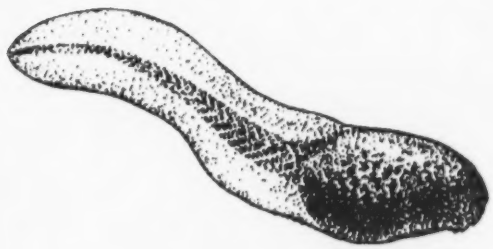
Habitat: pond **Immature**



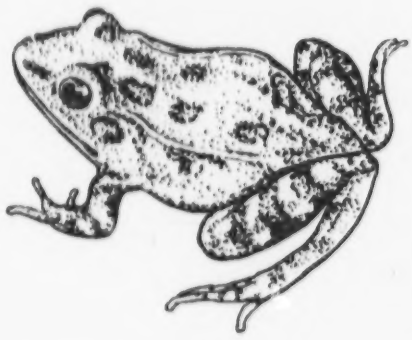
Habitat of larva: pond **Adult**



Habitat: pond, slow stream **Immature**



Habitat: pond, slow stream **Adult**



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Activity 4 Player's Cards

Body

Is camouflaged

Body

Has special attachments to hold onto slippery rocks

Body

Looks like a stick

Body

Has a hard armor

Body

Is soft and vulnerable

Body

Has a flat shape

Body

Has a streamlined shape

Breathing

Can live where there is little oxygen

Breathing

Breathes through gills located outside its body

Breathing

Must live where there is a lot of oxygen

Breathing

Uses a breathing tube to reach air

Breathing

Has breathing gills that look like tails

Activity 4 Player's Cards

Breathing

Carries its own air for underwater breathing

Breathing

Breathes through the surface of its body

Breathing

Creates a current to direct more oxygen toward its body

Movement

Has feet that feel the vibrations of other creatures in the water

Movement

Has three tails at the end of its abdomen that help it swim

Movement

Moves by expelling water from its body

Movement

Has paddle-shaped legs that help it move through water

Movement

Uses parts of its body other than legs to swim

Movement

Can fly through water

Eating

Has a mouth designed to collect tiny food particles

Eating

Prefers to eat other living things, using its big jaws

Eating

Can eat an animal fifty times bigger than itself

Activity 4 Player's Cards

Eating

Prefers to eat decaying things

Eating

Has a LARGE appetite

Eating

Injects chemicals that dissolve the internal body parts of its prey

Other Behaviors

Sees above and below the water at the same time

Other Behaviors

Hides from other animals

Other Behaviors

Burrows into the bottom of a stream or pond

Other Behaviors

Hides its head inside its body

Other Behaviors

Gives off stinky chemicals to ward off attackers

Other Behaviors

Avoids bright light

Other Behaviors

Lives on the surface of water

Other Behaviors

Lives in a protective structure it builds

Other Behaviors

Attaches to rocks with a safety line

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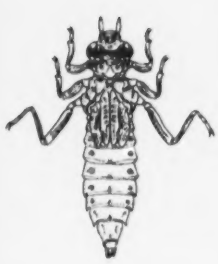
Activity 4 Leader's Cards

Is camouflaged **Body**

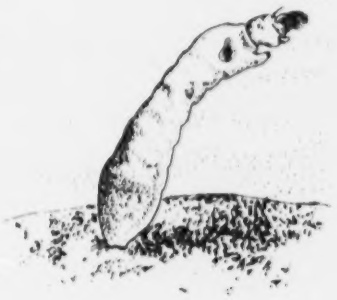


Dragonfly nymph

Stonefly nymph

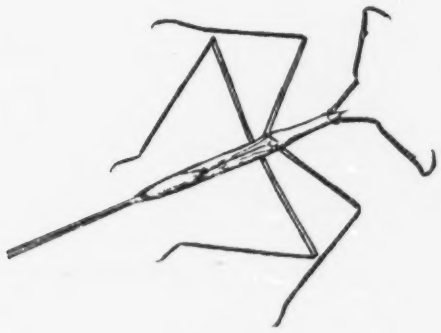
Mayfly nymph

Has special attachments to hold onto slippery rocks **Body**



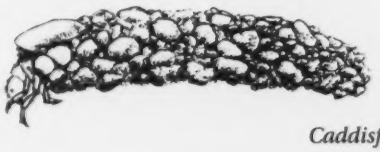
Black fly larva

Looks like a stick **Body**

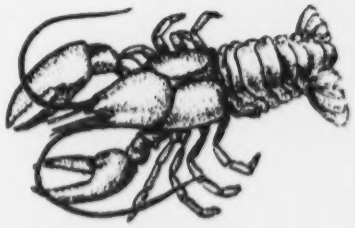


Water scorpion

Has a hard armor **Body**

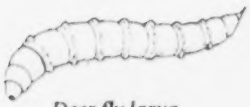


Caddisfly larva



Crayfish

Is soft and vulnerable **Body**

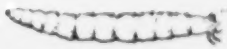


Deer fly larva

Midge larvae

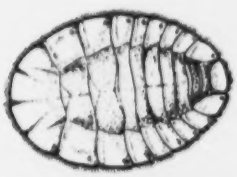
Black fly larva

Mosquito larva

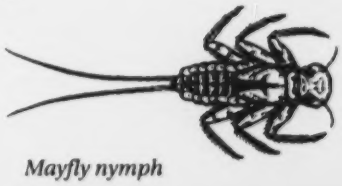


Crane fly larva

Has a flat shape **Body**



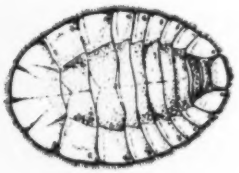
Water penny beetle larva



Mayfly nymph

Has a streamlined shape **Body**

Mayfly nymph



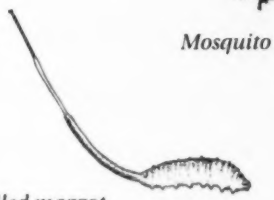
Water penny beetle larva

Black fly larva

Can live where there is little oxygen **Breathing**

Tubifex worm

Mosquito larva



Rat-tailed maggot

Breathes through gills located outside its body **Breathing**

Mayfly nymph

Stonefly nymph

Damselfly nymph

Must live where there is a lot of oxygen **Breathing**

Stonefly nymph

Black fly larva

Caddisfly larva

Mayfly nymph

Uses a breathing tube to reach air **Breathing**

Water scorpion

Rat-tailed maggot

Mosquito larva

Has breathing gills that look like tails **Breathing**

Damselfly nymph

Activity 4 Leader's Cards

Carries its own air for underwater breathing

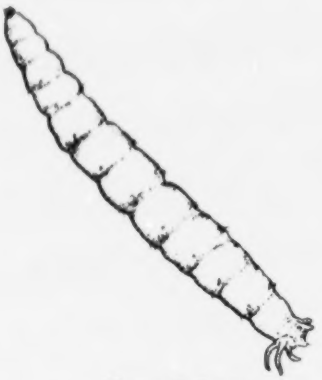
Breathing

Diving beetle

Backswimmer

Breathes through the surface of its body

Breathing



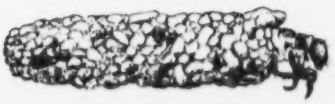
Crane fly larva

Creates a current to direct more oxygen toward its body

Breathing

Stonefly nymph

Mayfly nymph



Caddisfly larva

Has feet that feel the vibrations of other creatures in the water

Movement

Water strider

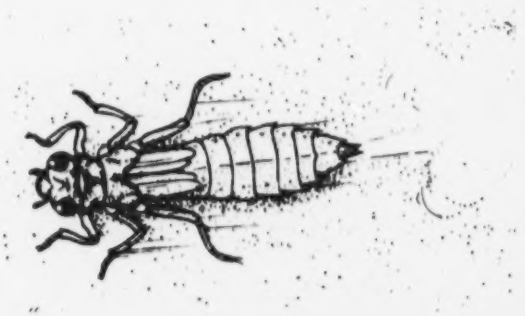
Has three tails at the end of its abdomen that help it swim

Movement

Mayfly nymph

Moves by expelling water from its body

Movement



"Jet-propelled" dragonfly nymph

Has paddle-shaped legs that help it move through water **Movement**

Backswimmer

Water boatman

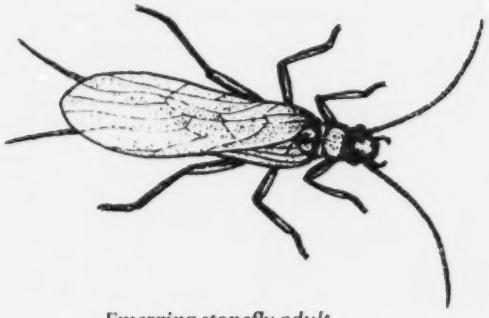
Uses parts of its body other than legs to swim **Movement**

"Jet-propelled" dragonfly nymph

Damselfly nymph

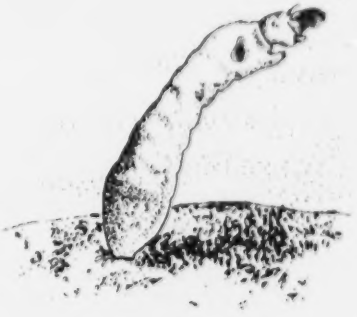
Mayfly nymph

Can fly through water **Movement**



Emerging stonefly adult

Has a mouth designed to collect tiny food particles **Eating**



Black fly larva

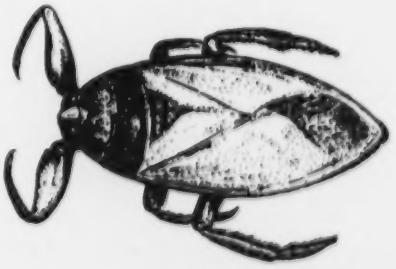
Prefers to eat other living things using its big jaws **Eating**

Damselfly nymph

Dragonfly nymph

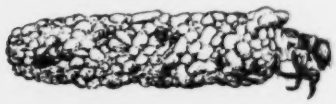
Dobsonfly larva (hellgrammite)

Can eat an animal fifty times bigger than itself **Eating**



Giant water bug

Prefers to eat decaying things **Eating**

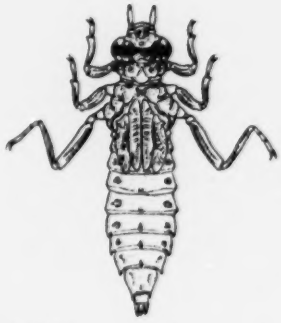


Caddisfly larva

Crayfish

Aquatic sowbug

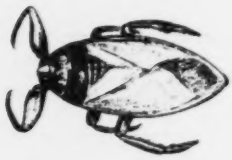
Has a LARGE appetite **Eating**



Dragonfly nymph

Dobsonfly larva (hellgrammite)

Injects chemicals that dissolve the internal body parts of its prey **Eating**



Giant water bug

Water strider

Backswimmer

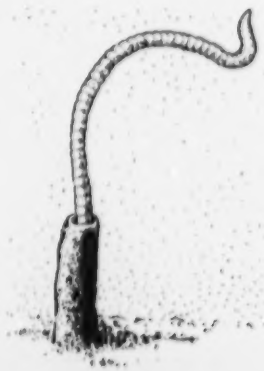
Sees above and below the water at the same time **Other Behaviors**

Whirligig beetle adult

Hides from other animals **Other Behaviors**

Dobsonfly larva (hellgrammite)

Burrows into the bottom of a stream or pond **Other Behaviors**



Tubifex worm

Hides its head inside its body **Other Behaviors**

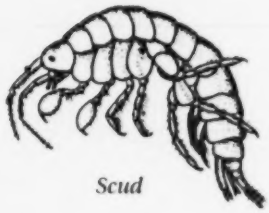
Crane fly larva

Gives off stinky chemicals to ward off attackers **Other Behaviors**

Whirligig beetle adult

Avoids bright light **Other Behaviors**

Stonefly nymph



Scud

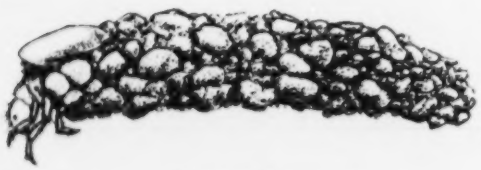
Caddisfly larva

Lives on the surface of water **Other Behaviors**

Water strider

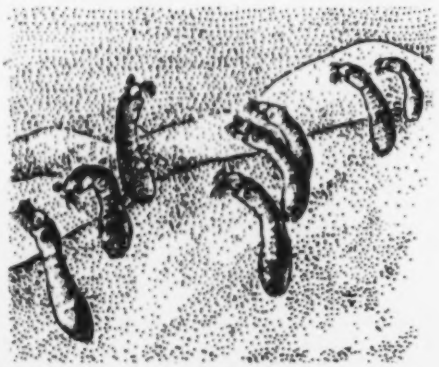
Whirligig beetle adult

Lives in a protective structure it builds **Other Behaviors**



Caddisfly larva

Attaches to rocks with a safety line **Other Behaviors**



Black fly larvae

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Activity 5 Work Sheet

Wanda and Willy Waterwatcher sampled different ponds and streams in their town to compare the life in one water environment with the life in others. Although they didn't have expensive instruments and equipment, Wanda and Willy were able to collect a variety of aquatic invertebrates. Before they set out, the Waterwatchers got special permission from the Department of Environmental Conservation to collect invertebrates and to preserve their samples in alcohol so they could show them to their classmates.

Wanda and Willy collected samples from three very different locations. Their day of sampling went well—except for one problem. The Waterwatchers didn't use permanent ink to label their samples, and the ink ran. Now they can't read the labels on the jars, which once indicated what sample came from which site. Can you help them?

Wanda and Willy have three jars of samples:

- One is from a rocky-bottomed stream in a forested park.
- One is from a sluggish stream near a factory that had pipes emptying a smelly liquid into the water.
- One is from a small pond in a neighbor's yard.

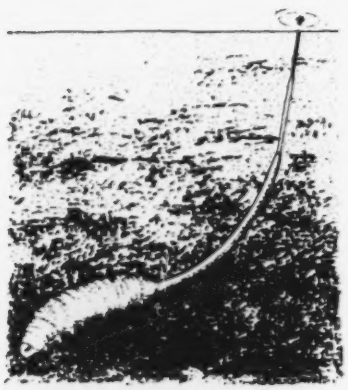
By looking at the animals in each sample, try to decide what group of invertebrates came from which sample site.

Sample A has

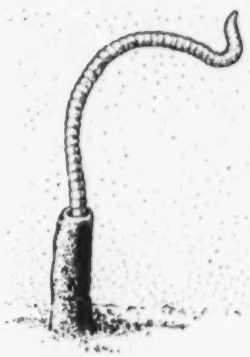
20 rat-tailed maggots

20 mosquito larvae

160 tubifex worms



Rat-tailed maggot



Tubifex worm

Mosquito larva

Hint: Interestingly, the Waterwatchers saw no fish at this site.

This sample came from (*circle one*)

- a rocky-bottomed stream in a forested park
- a sluggish stream near a factory
- a small pond in a neighbor's yard

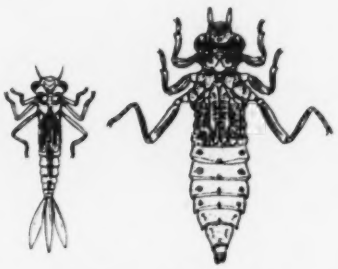
The water quality in Sample A seems to be (*circle one*)

excellent good poor

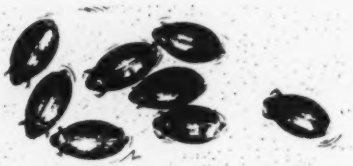
Sample B has

15 mayfly nymphs
20 damselfly and dragonfly nymphs
5 aquatic beetles
3 water scorpions
3 water striders
5 caddisfly larvae

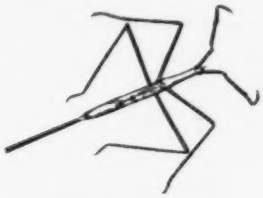
Mayfly nymph



Damselfly and dragonfly nymphs



Whirligig beetle



Water scorpion

Water strider

Caddisfly larva

Hint: The Waterwatchers also saw some bluegills and largemouth bass at this site.

This sample came from (*circle one*)

- a rocky-bottomed stream in a forested park
- a sluggish stream near a factory
- a small pond in a neighbor's yard

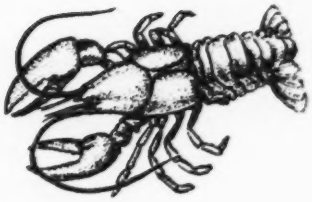
The water quality in Sample B seems to be (*circle one*)

excellent good poor

Sample C has

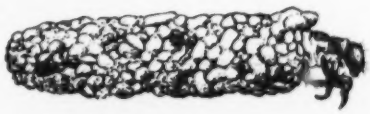
5 crayfish	30 mayfly nymphs
3 crane fly larvae	20 caddisfly larvae
2 hellgrammites	5 black fly larvae
35 stonefly nymphs	

Hellgrammite (dobsonfly larva)

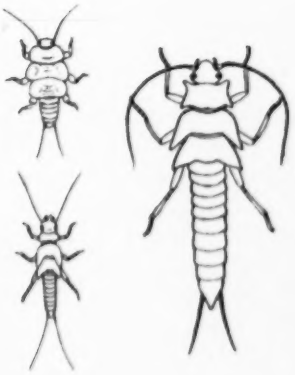


Crayfish

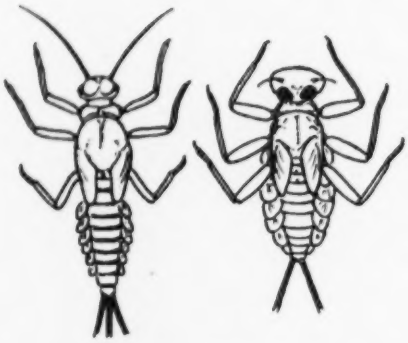
Crane fly larva



Caddisfly larva



Stonefly nymphs



Mayfly nymphs

Black fly larva

Hint: The Waterwatchers also saw brown trout and small minnows at this site.

This sample came from (*circle one*)

- a rocky-bottomed stream in a forested park
- a sluggish stream near a factory
- a small pond in a neighbor's yard

The water quality in Sample C seems to be (*circle one*)

excellent good poor

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Activity 6 Work Sheet

falymy The adult ___ ___ ___ ___ ___ ___ has a very short life, and it is eaten by trout as it first emerges from the water's surface or when it dies and falls back into the water.

ataihbts Fish and many insects live in aquatic ___ ___ ___ ___ ___ ___ ___ ___.

ertacsucan Scuds, a popular food of fish living in ponds, are a type of ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ and differ from insects because they have more than six legs.

verhibore An insect, a fish, or any other animal that eats plants is called a ___ ___ ___ ___ ___ ___ ___ ___ ___.

ponntkal Many insects and fish eat ___ ___ ___ ___ ___ ___ ___ ___, which are microscopic plants and animals.

trardpeo An animal that eats other animals is called a ___ ___ ___ ___ ___ ___ ___ ___.

eermge When insects ___ ___ ___ ___ ___ ___ as they become adults, they are often eaten by fish.

rerod Caddisflies represent one ___ ___ ___ ___ ___ of insects.

sligl Fish and some aquatic insects use ___ ___ ___ ___ ___ to take oxygen from the water.

mhnpsy Immature dragonflies, damselflies, stoneflies, and mayflies live in water and are called ___ ___ ___ ___ ___ ___.

soemtpamorhis When immature insects change into adults, they go through a process called ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___.

frflie The turbulent section of a stream where insects and fish are often found is called a ___ ___ ___ ___ ___ ___.

vesngcaer An insect, a fish, or any other animal that eats dead matter is called a ___ ___ ___ ___ ___ ___ ___ ___ ___.

tilfer To get food, fish and some insects ___ ___ ___ ___ ___ ___ feed, or strain food particles from the water.

nssees Hearing, seeing, smelling, and feeling vibrations are ___ ___ ___ ___ ___ ___ that fish and insects use to tell what is going on around them.

werat Fish and aquatic insects live in ___ ___ ___ ___ ___.

dofo Fish and insects are parts of the complex aquatic ___ ___ ___ ___ web because they are sources of food for one another.

asnoes Depending on the ___ ___ ___ ___ ___ ___, or sometimes even the time of day, different fish and different aquatic insects will be abundant.

relu Instead of live bait, anglers often use a ___ ___ ___ ___ to attract hungry fish because it imitates an insect or smaller fish that game fish like to eat.

ylfnogard Anglers use the term "bass bug" or "perch bug" to refer to a

___ ___ ___ ___ ___ ___ ___ ___ ___ nymph.

valear Immature flies, caddisflies, and beetles live in water and are called

___ ___ ___ ___ ___ ___.

sernnpi A dead mayfly adult floating and turning on the surface of water is called a

___ ___ ___ ___ ___ ___ ___. Imitations are used by anglers to catch fish.

sdolsvide Aquatic invertebrates breathe oxygen that is ___ ___ ___ ___ ___ ___ ___ ___ ___ in water.

gluebill A small panfish common to warmwater ponds and in the sunfish family is the

___ ___ ___ ___ ___ ___ ___ ___.

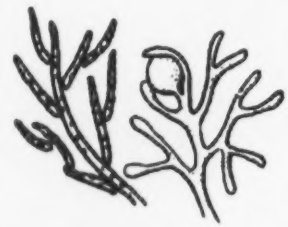
Hint: Here is a scrambled list of the answers:

bluegill	predator
food	gills
senses	dissolved
mayfly	season
larvae	riffle
habitats	order
crustacean	nymphs
dragonfly	emerge
water	metamorphosis
herbivore	lure
filter	scavenger
plankton	spinner

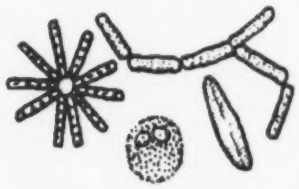
Special Message:

___ ___ ___ ___ ___ ___ ___ ___

Activity 7 Work Sheet

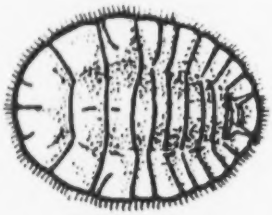


Bacteria and fungi

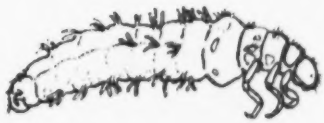


Algae and plankton

Mayfly nymph

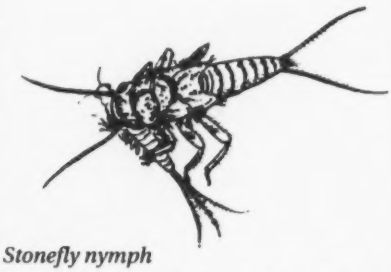


Water penny larva

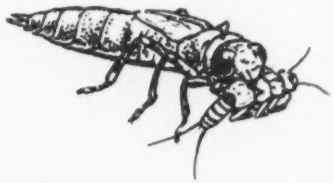


Caddisfly larva

Hellgrammite (dobsonfly larva)



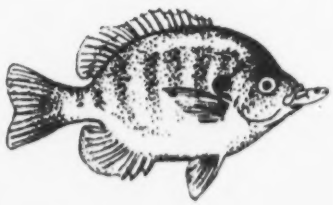
Stonefly nymph



Dragonfly nymph

Minnow

Catfish



Bluegill

Trout

Largemouth bass

Osprey

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